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U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Mail Station P1-127
Washington, D.C. 20555

Gentlemen:

Subject: Oyster Creek Nuclear Generating Station (OCNGS)
Docket No. 50-219
Reload Topical Report 045

Pursuant to your letter of May 12, 1986 concerning Topical Report 045 which was submitted to the NRC on September 29, 1987, please find attached the additional information requested. If there are any questions, please contact M. W. Laggart at (201)316-7968.

Very truly yours,

R. F. Wilson
Vice President
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ATTACHMENT

OYSTER CREEK NUCLEAR GENERATING STATION

GPU NUCLEAR TOPICAL REPORT 045

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

DATED MAY 12, 1988

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

1. Provide a detailed description of GPU's RETRAN hot channel model including justification of the void, flow and pressure profiles, and explain how his model is interfaced with the GEXL correlation computation. What is the "core 3-D simulator model" which is used to obtain the hot channel flow?

RESPONSE:

The Hot Channel Model is described in Section 2.1.2 of TR-045. A noding diagram is attached (Figure 1). The steady state and transient void, pressure and flow values are taken from the system model for the upper and lower plena. Steady state and transient power profile is also taken from the system model for the transient investigated. The output of the Hot Channel Model required for CPR calculation consists of core average pressure, hot channel flow, core inlet subcooling (or enthalpy) and hot channel power as a function of time during the transient. These parameters are then used in "RACE"[1] which is a GPUN code where the GEXL correlation is coded for transient and static CPR calculation. The justification of the axial power profile for the hot bundle (axial peaking of 1.4 - Table 4.6 of TR-045) is based upon the usual profile used by GE in NEDO24195 for Oyster Creek past reloads where the same profile has been used in RETRAN Hot Channel Model and in RACE. The Core 3-D Simulator Model which is used to obtain the steady state hot channel flow is the integrated NODE-B/THERM-B[2] which has been previously approved for thermal-hydraulic calculations representing the steady state behavior of the Oyster Creek Core. Once the hot bundle power and its axial profile are known (core average volumes power profile calculated from system model), hot bundle flow, bypass flow, upper and lower plena hydraulic conditions are determined, and the hot channel model is completely described.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

2. **What is the basis for the determination of 0.25% carryunder for licensing analysis?**

RESPONSE:

The carryunder fraction used for licensing analysis is 0.2% as stated in Table 4.2 of TR-045. The 0.25% on page 20 is a typing error. The carryunder (and carryover) measurements carried out at Oyster Creek during the Startup Tests (STP29)[3] showed an average carryunder of 0.1% at full power. A higher carryunder results in a reduction in core inlet subcooling which has a negligible impact on the CPR as shown in Table 4.4 of TR-045. TVA uses the same value (0.2%) in Section 2.3.3 of Reference (4) and showed the same conclusion on its impact on CPR (Table 7-1). GE also showed its negligible impact on peak heat flux in Table 6-1 of Volume 2 of ODYN Topical Report[5].

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

3. Explain the apparent excess lag time evident throughout this Topical Report in the RETRAN control system in computing feedback.

RESPONSE:

Certain details of the control systems, in particular the pressure regulator, that have short response time have been ignored in the basic RETRAN model. The functional requirements of the control system model dictates that the model should be as stable as the actual system and should have an "adequate" response (in amplitude and time). The acceptance criteria, stated on pages 51 and 52 of TR-045, are generally satisfied. The impact of the control systems on the three reload transients results is negligible because the turbine stop valve closure in TTWOBP and FWCF transients effectively isolates the pressure control of the main regulator and the bypass opening for the FWCF effectively terminates the transient very quickly. In the MSIV transient, the MSIV closure controls steam flow through the steam lines. The feedwater control system has, likewise, negligible effect because it is assumed to fail in FWCF transient and the feedwater transient time under forced circulation, from feedwater sparger to core inlet, for the other transients, is well over the eight second transient time used in the analysis.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

4. What basis was used to determine that 15% error margin between RETRAN and data was the acceptable level? Similarly, on what basis was the assumption of 10% error margin for the plant data? How well did the computed key parameters on Table 2.2 compare with the actual data after initialization of the RETRAN code. Provide the measurement uncertainties for parameters on Table 2.2.

RESPONSE:

The basis for the 15% total error margin and the 10% error for plant data is documented in Section 3.0 pages 51 and 52 of TR-045. It is to be noted that this margin is not applied to the absolute value of a parameter, but rather to the maximum change (delta) from the steady state. The bases used in establishing that the error level used is acceptable were the following:

- Setpoints for Reactor Protection System and Safety Systems actuation are not incorrectly challenged, i.e., scrams, pump trips, relief valves actuations, etc. are occurring in the correct order as shown on plant data and tests description. For example, if RETRAN's calculated dome pressure shows such a margin to actual measured plant pressure that a recirculation pump trip on high pressure occurs in RETRAN, then obviously such a margin is not acceptable.

- The absolute difference between RETRAN and plant data for the maximum change in a parameter (delta) from the steady state should be within two standard deviations of the uncertainties in plant measurement. The change from steady state is used in order to reduce measurement and calibration errors and because RETRAN steady state boundary conditions (Section 2.4 of Reference 6) are within 1-3% of plant average steady state conditions for the various tests. as explained below. Table 1.0 shows plant parameters and the one standard deviation values.

All benchmarks passed these criteria for the main parameters except the turbine trip test where a more conservative response was established. Secondary parameters that did not were addressed individually.

Table 2.2 of TR-045 represents the boundary conditions for the licensing model. They compliment Table 4.2. The measurement uncertainties are documented in Table 5-1 of NEDO-24195. The startup tests were carried out when the plant power was 1600 MW (Oyster Creek was upgraded to 1930 MW a few years after initial operation), and rated dome pressure of 1000 psig compared to present ratings of 1020 psig. The RETRAN boundary conditions used for the startup tests (after steady state initialization) are given in Table 2.2 of Reference (6). Table 2 gives RETRAN steady state parameters and the corresponding plant initial conditions for each test.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

5. Comparison of the RETRAN output to only two plant parameters, as has been done generally throughout the report for the startup tests, is insufficient to evaluate the adequacy of the computer model; therefore, please compare to other available test data, or, if unavailable, provide plots of computer output, and explanation/correlation of the results of sufficient parameters to adequately define and describe these transients.

RESPONSE:

Reference (6), which was previously submitted to the NRC, details all parameters that were available from the tests. In general, parameters that do not show variations beyond the uncertainty or (noise) level are not plotted. Measurable reactor parameters that have been used in the comparison over the nine startup tests include power, pressure, level, recirculation flow, feedwater flow, steam flow and pressure regulator pressure signal.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

6. For the comparison of pressure regulator test data, it does not appear that the percent power change trace is well matched; RETRAN predicted a much slower repressurization and much broader peak leading to a complete lack of prediction of the peak in power at 90 sec. Provide plots of other parameters and discussion of how this analysis verifies core thermal hydraulics (T/H) and physics.

RESPONSE:

It has been stated in the answer to question 3 that certain details of the pressure regulator have not been modeled due to their short time constant as compared to the overall regulator time constant. Between blocks -5 (Integrator) and -24 (Summer) of Figure 2.3, there exists a servo loop which would accelerate the positioning of the control valve and stabilizes the valve positioning integrator (-5) very rapidly. This loop is not modeled and its impact is to lengthen the period required to discharge and stabilize integrator (-5). This is quite apparent on Figure 3.1.1 where the model fails to follow the dip in plant response at 80 seconds which preceded the repressurization phase. This does not happen during the initial depressurization phase because this integrator has been correctly set during the steady state initialization stage. A slower repressurization rate produces lower power peak and a slightly different behavior as seen in Figure 3.1.2. This is an acceptable model limitation which does not impact any of the reload transients because such repressurization behavior where the pressure regulator is involved is not encountered.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

7. **RETRAN seems** to have completely missed the overshoot in downcomer (DC) water level in the comparison of data for the level setpoint change test. Explain the leveling off at the higher value of DC water level by the calculation and provide an assessment result of the impact for other transients.

RESPONSE:

It is strongly suspected that the inability to detect the overshoot is due to the uncertainty in the regulating valves characteristics where a straight line between the fully closed and the 100% flow open positions is used to represent flow vs stroke. No details are available on the old valve which was replaced a few years ago. The maximum deviation between RETRAN and plant data at the overshoot location is three inches which is within measurement uncertainty. There is no impact on the reload transients because the TTWOBP and MSIV closure without scram transients are pressurization transients which are practically terminated before the impact of level can be seen on the core because of the transport time involved. Obviously in the FWCF transient the feedwater controller is assumed to fail. In the present reload model, the new regulating valve end points are also used with a connecting straight line.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

8. Why is the peak computed dome pressure at peak is more than 15% different from the MSIV closure test data? What caused the computed dome pressure to go up at about 15 seconds while the test data remained flat. Provide and discuss power plot comparisons.

RESPONSE:

See Section 3.5, page 64 of Reference (6). The deviation is due to the use of the wide range reactor pressure monitor which is not as accurate as the narrow range monitor which goes off scale at the low end when pressure is below 970 psig, which was the case in this test.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

9. Explain why (a) the plots provided in the report indicate nearly 35% difference between the computed and measured changes in pressure signal data, and (b) the RETRAN model appears to have too much hysteresis as compared to the bypass valve test data.

RESPONSE:

(a) The peak dome pressure change given by RETRAN in Figure 3.4.1 for the bypass valve test was 3.5 psi compared to 3 psi given by plant data. This shows approximately 15% margin for plant data relative to RETRAN. The timing is off by about 2 sec. and if a similar measurement error is applied to the time scale, a better agreement would be obtained. The justification of time scale error bound is thought to be legitimate considering the available plant data for this test, shown in Figure 2.

(b) The Hysteresis effect may be amplified in the figures, but a closer look at plant data, Figure 2, shows the difficulty in arriving at this observation considering the noise level on the output and the signal magnitude of 3 psi out of an operating pressure of 1000 psi which puts it well within the uncertainty level of Table 1.0.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

10. RETRAN underpredicted the dome pressure rise between 0.5 and 1.5 seconds, yet nearly double the power rise as compared to the turbine trip test data. This is an indication that the core T/H and physics computation may be inaccurate. Explain and justify the difference and how this would impact other transients.

RESPONSE:

The correlation between dome pressure and core neutronic power is influenced by certain characteristics of the regions between the dome and the core. For the separator, an important contributing factor is the separator inlet inertia. Figures 3 and 4 are plots of an earlier model where the steam path length inside the separator was used for calculating the inlet junction inertia which resulted in a small inertia value. The plots show an earlier power rise and a better prediction for the pressure increase early in the transient, but underpredicted the peak dome pressure. The inertia was then recalculated using the liquid path resulting in a higher value which produced more energy and conservative peak dome pressure as shown in Figures 3.5.1 and 3.5.2 of TR-045, although the power peak is at the same level, but delayed. The Cycle 1 startup test scram model assumes all control rods move at the same time and at the same speed while in reality, all rods do not start at the same time and do not start moving with the same speed. This assumption tends to insert more scram reactivity in the beginning which would limit the void collapse positive reactivity produced by the pressure wave and hence causes a delay in the power increase and results in a higher peak in RETRAN. With the high control rod density of Cycle 1, this is an important contributing factor. This effect was also seen in the ODYN Topical Report, Volume 2, Section 3.1.3.2 for the Peach Bottom tests[5] benchmark. The objective of the model, as required here, is to predict conservative peak power and peak pressure which has been demonstrated. The licensing model uses the vendor's supplied inertia which is still higher than the best estimate value and it also uses the same scram model assumption of all rods traveling at the same time. Therefore, the licensing model will produce even more conservative behavior (Section 4.1.2b).

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

11. Explain the apparent excessive hysteresis in the RETRAN computation for comparison with the generator trip test data.

RESPONSE:

The dome pressure response in the generator trip test, Figure 3.6.2, is dictated to a large extent by the operation of the bypass valves. There are nine bypass valves which are individually modeled and assumed to operate sequentially, i.e., when one valve is fully open the next one starts opening immediately. The underprediction of pressure in the early part is most probably due to the assumed design capacity of the bypass system of 40% while the real capacity may be somewhat larger than the 40%. The ODYN model of Peach Bottom also overpredicted the dome pressure in the three Turbine Trip Tests[5], Section 3.1.3.1, and it was attributed to an actual bypass capacity which is higher than the design value resulting in a more conservative model response. The shift in timing for the power response in Figure 3.6.1 of approximately 0.2 seconds is believed to be due to the same factors discussed in question 10 for the turbine trip because it is a pressurization transient although less severe than the turbine trip.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

12. The calculated RETRAN coastdown curve is much steeper than the recirculation pump trip test data. If this was used to adjust pump coefficients, the adjustment appears to be inaccurate. Explain and justify impact on transient analysis.

RESPONSE:

The recirculation pump friction coefficients were adjusted to match pump coastdown curve. The initial part of the coastdown curve is also sensitive to the pump system inertia. The system inertia used was based on design values for the different components as supplied by the vendor. With the best adjustment possible to the friction coefficients, the calculated curve is steeper than actual curve for the initial part. The impact of this response is to deprive the core of otherwise higher coolant flow immediately after the trip. For pressurization transients where pump trip is on high dome pressure when power is still high, this kind of response contributes to a higher heat flux and hence a conservative response. This can be seen on Figures 4.1.1, 4.1.2, 4.1.5, and 4.1.6 of the Turbine Trip Without Bypass reload transient.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

13. For test B of the power-flow control test, RETRAN substantially underpredicted the decrease in power (by a factor of 2). How does higher liquid level result in lower power? Explain why RETRAN underpredicted the dome pressure for virtually the entire test period.

RESPONSE:

The initial power decrease predicted by RETRAN is steeper than plant response where 10 seconds into the test, RETRAN predicted change in power was approximately 20% compai _ 11% for the plant then RETRAN recovers very quickly and the corresponding values 10 seconds later were 13% for RETRAN compared to 11% for the plant. The steep initial response is due to the unavailability of test data for the flow reduction involved in Test B and the same flow response as for Test A was used (see Section 3.8 of TR-045 and Section 3.10 of the Startup test document, Reference 6). The master flow controller is not modeled in RETRAN. There is no impact of this behavior on the reload transients because the recirculation pumps trip and no flow control is involved. The correlation between level and power is not direct in a BWR-2 when recirculation pumps are involved. When a recirculation pump is started, there is an immediate reduction in level due to the pump suction effect and conversely when a pump is tripped there is an immediate increase in level until it recovers by the feedwater controller. The level increase predicted by RETRAN and shown by plant data does correspond to pump behavior and it does recover some 300 seconds later as shown on test results[3]. Figure 3.8.2 of TR-045 shows the response to 120 seconds where RETRAN and plant show excellent agreement after 60 seconds. It should also be pointed out that the maximum level change is approximately 3" which is within two standard deviations of measurement uncertainties of Table 1. The plant data for the dome pressure showed a high noise level (see Section 3.0 of Reference 6) and the difference between RETRAN and plant data is approximately 8 psi which is within the two standard deviations of Table 1.0 for dome pressure.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

14. Justify the statement in Section 3.9, isolation condenser test, that "the 1-D kinetics gives a closer response to the plant output" in view of the 20% d[illegible]nce in heat removal.

RESPONSE

The 20% di[illegible] in heat removal is independent of the kinetic model used, but rather [illegible]erate model design. The isolation condensers total design capacity is [illegible]ated power (3% each) while actual test data showed that actual capacity is 20% over design (Section 3.9 of TR-045). The 1-D kinetics shows a similar trend as plant data between 10 to 60 seconds as compared to point kinetics. The 20% difference which is due to design vs. actual capacity is more consistent between 1-D and plant data as compared to point kinetics in the above time range.

15. Relative to the sensitivity analysis presented in Section 4.1.2, explain how the CPR variabilities due to uncertainties in the system parameters were combined to yield an overall CPR multiplier.

RESPONSE:

The variables are statistically combined using the equation on page 98 in the Topical Report. See response to question 21 for more details.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

16. What is the reason that a sensitivity with respect to the mixture level in the separator need not be performed for each transient? Provide the justification for the assumption that the separator mixture density is approximately the same as the standpipe average mixture density. Since this assumption would provide a higher mixture density in the separator and a higher water level, assess its impact on the overall transient outcome.

RESPONSE:

The impact of mixture level on transient outcome is discussed on page 86 for the limiting TTWOBP transient where it was shown it has very little effect on peak power. The impact on the FWCF and MSIVATWS transients is the same because they are similar (pressurization) transients.

The difference in density between the standpipes and the separators is practically determined by the pressure at both volumes because negligible heat addition or removal is involved in both volumes. Although two sided heat conductors representing the standpipes and separators materials are modeled to represent heat conduction to the upperdowncomer, there is negligible temperature gradient across these conductors because the upperdowncomer is at saturated conditions (the same as the separators and standpipes). Since the feedwater sparger for Oyster Creek is at the upper plenum elevation, the subcooled region is limited to the lowerdowncomer.

The pressure difference between the separators and standpipes is less than 5 psi (see Table 2.3 page 35 of Reference 6) and the change in saturated water density at operating pressure is less than 0.2%, therefore the assumption of using the standpipe mixture density is thought to be acceptable.

17. For the turbine trip without bypass event, (a) justify the use of the default Courant number in the early portion of the event and how it influences the dome pressure, relief valve flows and the core boil-up level; (b) if the relief valves (RVs) are opened on high dome pressure, explain why the RETRAN RVs open before the ODYN RVs, yet the RETRAN dome pressure is lower in the time period prior to relief; (c) explain why the RV flows are the same when the dome pressures differs; (d) explain in detail the differences between the core mixture levels predicted by these two codes; (e) explain the impact of the failure to use the same modeling of the feedwater piping as GE does, and why the core inlet flow was computed to be lower by RETRAN (since the feedwater flow continued longer for the RETRAN computation).

RESPONSE:

(a) The default Courant number is 0.3 of the Courant transport time for the mixture flow. This is the lowest Courant limit used. It is used during the first two seconds of the TTWOBP transient because of the severe changes taking place during this time. Relaxing this limit to values greater than 0.3 during this interval was found to produce lower power peak which will subsequently result in lower dome pressure, and delayed relief valve opening.

(b) The RVS open at 1085 psia, equivalent to a pressure rise of 50 psi which puts it on the 0.5 to 0.7 second time scale where ODYN and RETRAN are close. The noding scheme for the steam dome in ODYN Is different from RETRAN. The former has one node which starts from slightly above the feedwater sparger to the top of the vessel, see Reference 5, Volume 1, Figure 4-1C, while RETRAN representation of the same space is 3 nodes (108, 103, 104). The impact of this difference in modeling is that ODYN dome pressure is equivalent to the average pressure of the above three volumes in RETRAN while RETRAN dome pressure represents volume 104 where the pressure sensor is located. During the TTWOBP pressurization event, the pressure wave traveling through the steam lines towards the vessel will be felt earlier in volume 104 (RETRAN) than ODYN thus causing the Relief Valves to open in RETRAN before ODYN. This is not reflected in Figure 4.1.2 because of the plot resolution considering that the time step size during the first two seconds was 2 msec while the plot resolution was 0.1 seconds.

17. CONTINUED

RESPONSE:

(c) RETRAN correctly calculates the RV flow rates because an increase of 50 psi in pressure (t = 2.5 to 6 sec.) produces an increase of approximately 35 lbm/s using Moody's tables, which is what RETRAN shows. It seems that ODYN uses different choking models. However, the impact of this difference is negligible because it happens well after the minimum CPR has occurred (around 1 second).

(d) The level response shown on Figure 4.1.4 is a collapsed liquid level plot and not a mixture level. It is the upper downcomer level monitored by the level instruments and not the core mixture level. RETRAN uses the new regulating valve while ODYN was probably using the old valve which used to give rated flow at 40% open position while the new valve gives rated flow at 70% open. The impact of this difference is a different flow for the same fractional demand in valve stroke and with the older valve it gives a higher change in flow. The initial reduction in steam flow will result in a reduced demand for feedwater and this reduction in feedwater will be more in ODYN than in RETRAN thus causing a different level response due to the void collapse. Again, there is no impact on CPR for the same reason as in (C) above.

(e) GE does not model the feedwater piping in their ODYN model. As stated before, downcomer level has no impact on CPR because the minimum CPR occurs about 1 second into the transient and deviations in level start appearing after 2 seconds, and the level deviation around 1 second is less than two standard deviations of 3.2". The core inlet flow as shown in Figure 4.1.5 is lower than ODYN because recirculation pumps trip on high dome pressure results in a steep pump coastdown immediately after the trip (Q12) which causes a larger reduction in core inlet flow than ODYN thus helping to drive the heat flux up (Figure 4.1.6) in a conservative direction.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

18. For the main steam isolation valve closure without scram event, repressurization, water level reduction, and power peaking occur slower for RETRAN than ODYN even though the valve closure times are virtually identical. Explain in detail and justify the difference in kinetics models which are stated to cause the differences in computed behavior. In particular, since the GE computation generates a broader, earlier and higher peak, justify that the RETRAN kinetics produces conservative (or best estimate, if that was the intention) results. Also, explain (a) why the RETRAN computation had higher heat flux from lower power, and resulted in lower dome pressures, and (b) the differences in safety valve flows vs. dome pressures, and in feedwater flow vs. water level change and core inlet flow.

RESPONSE:

It is not our objective to benchmark against ODYN but rather to show that RETRAN produces comparable results. The main benchmark was against the plant as shown before. There are a number of differences in modeling the plant, solution methods, etc. Some of the modeling differences that we know would have an impact on the response between the two are:

1. The detailed RETRAN noding of the upper part of the vessel from the upperdowncomer to the steam dome (Volumes 108, 103, 104) as compared to an average volume in ODYN and the nine nodes/steam line (dome to stop valve) in RETRAN as compared to six nodes in ODYN results in an earlier arrival to the core of the pressure wave in ODYN which results in an earlier void collapse and power rise.

2. It is not known what ODYN has for the isolation condensers which are modeled in detail and benchmarked in RETRAN. These act as "shock absorbers" to an incoming pressure wave. It was found that when those are isolated (disconnected from the vessel), a higher power is obtained because the isolation condensers steam lines act to increase the volume available to dissipate a pressure wave before it reaches the core.

3. The recirculation pump's coastdown are steeper in RETRAN which means they will deprive the core from flow thus increasing the heat flux which is a function of energy generated and core flow available to remove it.

4. Differences in conduction models specifically gap conductance and number of nodes in the pellet and clad. These will impact void generation and feedback.

18. CONTINUED

RESPONSE:

5. Differences in kinetics methods which will generate slightly different axial profiles. It was found that shifting the axial peak one node up or down (in a 24 node core) will change the power profile.

In the MSIV closure event, the repressurization and power peaking differences are believed to be due to items 1 and 5 above. Water level reduction and feedwater flow are believed to be due to feedwater regulating valve response differences. The kinetics method used by GPUN[1] are based on SIMULATE/SIMTRAN codes and the details of GE kinetics methods are not known to us. Comment (5) above is applicable.

(a) Item 3 above explains the heat flux behavior.

(b) Safety valves flow differences are because more valves opened by ODYN than RETRAN (2 more valves for 3 seconds) because of higher pressure. The earlier level drop (Figure 4.2.5) in ODYN is because of the earlier pressure rise producing a void collapse in the core which will redistribute the liquid inventory between the core and downcomer region. The early recovery in ODYN of level is due to void generation in the core following the power increase, i.e., another redistribution of liquid inventory following a change in core void content. Changes in core inlet flow are discussed in (3) above.

The overall kinetics and hydraulics of the Oyster Creek RETRAN model assure a conservative pressure response in this transient. This conclusion is based on the conservative pressure response of RETRAN in the Turbine Trip and the Generator Trip Startup Tests (Figures 3.5.2, 3.6.2). The added conservatism of the licensing model through the use of limiting values for the parameters discussed in Section 4.1.2 will assure an added conservatism to an actual response.

19. Figure 4.3.2A indicates that the ODYN computation produced considerably more energy than the RETRAN computation. Explain how this resulted in RETRAN predicting more conservative CPR results than GE's result using ODYN. Also, discuss comparisons of the RETRAN predictions for power, dome pressure and water level and the ODYN results.

RESPONSE:

A larger area under the power vs. time curve of Figure 4.3.2A does not necessarily mean higher CPR. It is the power and flow through the core that dictate the heat flux. Inspection of Figures 4.3.4 and 4.3.5 shows that RETRAN calculates higher heat flux which is, to a large extent, due to the steeper recirculation pump coastdown on the high pressure pump trip. The deviation in power fall under the general comments made in Q18 while the dome pressure response is possibly because of the larger energy production in ODYN which would produce more steam and hence higher pressure. The level response has been addressed in Section 4.3 of TR-045.

REVIEW QUESTIONS ON THE GPU TOPICAL REPORT TR-045

20. Provide a detailed description and justification of the nodalization and phenomenological models used for licensing applications. Discuss sensitivity studies performed to support your selections.

RESPONSE:

The nodalization method used is presented and discussed in detail in Section 2.1 of TR-045. The nodalization scheme presented was based on GPUN in-house experience over the years as stated in Section 2.0. Basically, four major areas of the NSSS were investigated as discussed below:

1. Steam Lines: Originally 2 node steam lines were used, but found to be inadequate in capturing the dome pressure, peak power, and timing in pressurization transients (Turbine Trip with Bypass and Generator Trip with Bypass). Larger noding schemes were investigated where it was shown by GE in ODYN[5] that six nodes are adequate for licensing applications. An 8-node steam line (dome to steam chest) was chosen because it fits the geometry and layout of Oyster Creek steam lines.

2. Separators/Upper Downcomer/Dome: Different noding schemes were investigated[7] where parameters and effects of primary importance were separators inertia, carryunder, and carryover downcomer level, pressure drops and the non-equilibrium effects during pressurization transients. The noding scheme chosen was found to represent and capture above stated requirements and effects.

3. Core: A 12 node core was chosen for a better representation of the 1-Dimensional kinetics effects where void collapse effects in the top portion of the core and the importance of the bottom nodes during initial control rod entry during pressurization transients are properly captured. The initial 3-node core was completely inadequate.

4. Lower Downcomer, Recirculation Loops and Lower Plenum: A one node lower downcomer has been used because this is the subcooled region and level does not drop below the feedwater sparger in any of the reload transients analyzed here. The recirculation loops noding scheme is based on the same arguments as for the lower downcomer and the one and four loop combination to represent the 5 loops was required to benchmark the isolation condenser test. The lower plenum one volume representation is adequate for the same reasons.

20. CONTINUED

RESPONSE:

The adequacy of the nodalization is basically judged by the benchmark against plant data, which we have demonstrated over nine startup tests. The same nodalization is used in the licensing model, as stated in Section 4.1.1 of TR-045 and the reload transients analyzed (TTWOBP, MSIVATWS, FWCF) were shown to give comparable results against another methodology namely GE's (comparisons against ODYN for Cycle 10 reload). It can, therefore, be stated that no further sensitivity analysis is needed for the nodalization scheme.

The phenomenological models used are those built in the RETRAN code. The applications where user options are given have been addressed in the report and those were the non-equilibrium model for the separator/downcomer, the algebraic slip and subcooled void profile. The use of the non-equilibrium option is discussed in Sections 2.1.1 and 2.1.2 and no sensitivity analysis was presented on equilibrium vs. non-equilibrium. TVA (Section 7.1.3 of Reference (4) did such a comparison and showed, as expected, that the equilibrium model is less conservative. In-house experience over the years showed that the non-equilibrium separator and a non-equilibrium upper downcomer should be used to simulate pressurization transients. The sensitivity study of algebraic vs. dynamic slip options is discussed on page 98, Section 4.1.2 of TR-045. The subcooled profile fit should be used because it represents the subcooled boiling phenomenon which plays an important role in the transients analyzed and its sensitivity is presented in Table 4.4 of TR-045.

21. Discuss the impact on determination of MCPR limit affected by uncertainties in the computer code (including the uncertainties for coefficients used in the correlations) and other approximations including engineering judgment factors used in the statistical analysis. Demonstrate that the system parameters used in the perturbations are statistically independent so that they can be combined in the manner via equation on p. 98 in the Topical Report and that this will result in 95/95 probability confidence level.

RESPONSE:

While an evaluation of uncertainties in the computer code (correlations, numerical algorithms, etc.) was beyond the scope of TR-045, it has been done as part of the RETRAN code development in separate effects analyses and system effects analyses of the correlations and code models[8]. The models were concluded to be acceptable by the code developer. These correlations, algorithms, etc. were reviewed by the NRC as part of a generic review of the RETRAN code and found to be acceptable. Given the acceptability of these correlations, algorithms, etc., it is not necessary to evaluate these uncertainties individually to make an assessment of their impact on the determination of the MCPR limit. The approach used by GPUN to develop an Oyster Creek model that will conservatively (in terms of MCPR) represent plant transient responses insures that these uncertainties are not an issue with regard to the MCPR limit. This is supported by the ΔCPR calculated by RETRAN for the TTWOBP (page 100) and the FWCF (page 105) which are consistently higher than previously licensed analyses and further accounting of these uncertainties is not necessary. A similar argument can be made for approximations and engineering judgment factors used in the statistical analysis. The overall response of the model is conservative and that the combination of uncertainties in the system parameters will add further conservatism to the MCPR limit.

The perturbations shown in Table 4.4 of TR-045 are maximum deviations from an observed, measured or calculated values. These are error values. Accordingly, the issue is, are those error values statistically independent? i.e., does knowledge of the error in the direct moderator heating (Table 4.4) improve the knowledge about the magnitude of the error in the gap conductance, or the void profile fit or the ΔP across the core? If the answer is "no", then errors in the direct moderator heating are independent of errors in the other parameters. When this argument is applied to each error in core parameters in Table 4.4, the answer will be "no". The same conclusion will be obtained for the separators, recirculation loops, and the vessel parameters. For the steam lines, a "no" will be obtained for the ΔP measurement error, but a "yes" answer will be obtained for the volume and inertia. This is because uncertainty in volume calculation was assumed to be due to error in measuring pipe length and error in length will be reflected in errors in

21. CONTINUED

RESPONSE:

inertia which is calculated from length and area (L/A). As seen from Table 4.4, reducing volume (by reducing length, see Page 94) will increase ΔRCPR, but it will reduce inertia which will reduce ΔRCPR. The approach used in the sensitivity analysis was to reduce volume, but leaving the inertia the same then increase inertia and leave the volume at its original values. In this manner, error in volume has been made "independent" of error in inertia. This is a conservative approach because it produces an increase in ΔRCPR for both uncertainties. It needs to be stated that we are discussing the statistical independence of the errors in Table 4.4 and not the parameters because the statistical independence of the parameters may not be true at all due to their functional dependence through the conservation equations and the equations of state. The uncertainties assumed in Table 4.4 represent upper limit values which are higher than even the 2σ level for each parameter. The resultant uncertainty in ΔRCPR calculated as shown on page 98 will therefore represent a 95% probability (at the 95% confidence level) that the calculated ΔCPR will be an upper bound limit.

REFERENCES

1. Information sent to NRC in December 1987.

2. R. V. Furia, "Methods for the Analysis of Boiling Water Reactors Steady State Physics," GPUN TR-021-A, 1988.

3. M. J. May, "Oyster Creek Startup Tests," NEDE-13109, 1970.

4. S. L. Forkner, et. al., "BWR Transient Analysis Model Utilizing the RETRAN Program," TVA-TR81-01, 1981.

5. "One Dimensional Core Transient Model," NEDO-24154, 1978.

6. M. A. Alammar, "Oyster Creek RETRAN Model Startup Tests Benchmark," GPUN TDR 824, 1986.

7. M. A. Alammar, "Comparison of RETRAN and RELAP5 Models to Oyster Creek Loss of Feedwater Transient," Nuclear Technology, 70, pp. 111-119, 1985.

8. "RETRAN-02 - A Program for Transient Thermal Hydraulic Analysis of Complex Fluid System," Volume 4: Applications, EPRI NP-1850-CCM, 1983.

Table 1.0

Measurement Uncertainties (1600 MW)

Parameters	Units	Nominal Value	One SIGMA	Basis
Feedwater Flow	lb/S	1670	30	GETAB
Reactor Pressure	psig	1000	5	GETAB
Core Flow	MLB/HR	61	3.05	GETAB
Power	MW	1600	16	Judgment
Level	Inches TAF	160	1.6	Judgment

Table 2

RETRAN and Startup Tests Initial Conditions

Startup Tests	Power MW	Feedwater MLB/HR	Core Flow MLB/HR	Dome Pres. PSIG	Level In TAF
RETRAN	1615	6.0	61	1000	160.8
Pressure Regulator	1570	5.8	61	998	158.2
Level Setpoint	1570	5.75	61	998	157
MSIV Closure	1581	5.8	61	1000	154.6
Bypass Valve	1570	5.8	61	1000	158.2
Turbine Trip	1591	6.0	61	1000	152.2
Generator Trip	1585	6.0	61	998	157
Recirc Pump Trip	1579	N/A	61	1000	163
Power Flow	1571	5.9	60.6	1000	151
Isolation Condenser					
RETRAN	202	0.83	61	1000	160.8
Plant	200	0.875	58	990	163

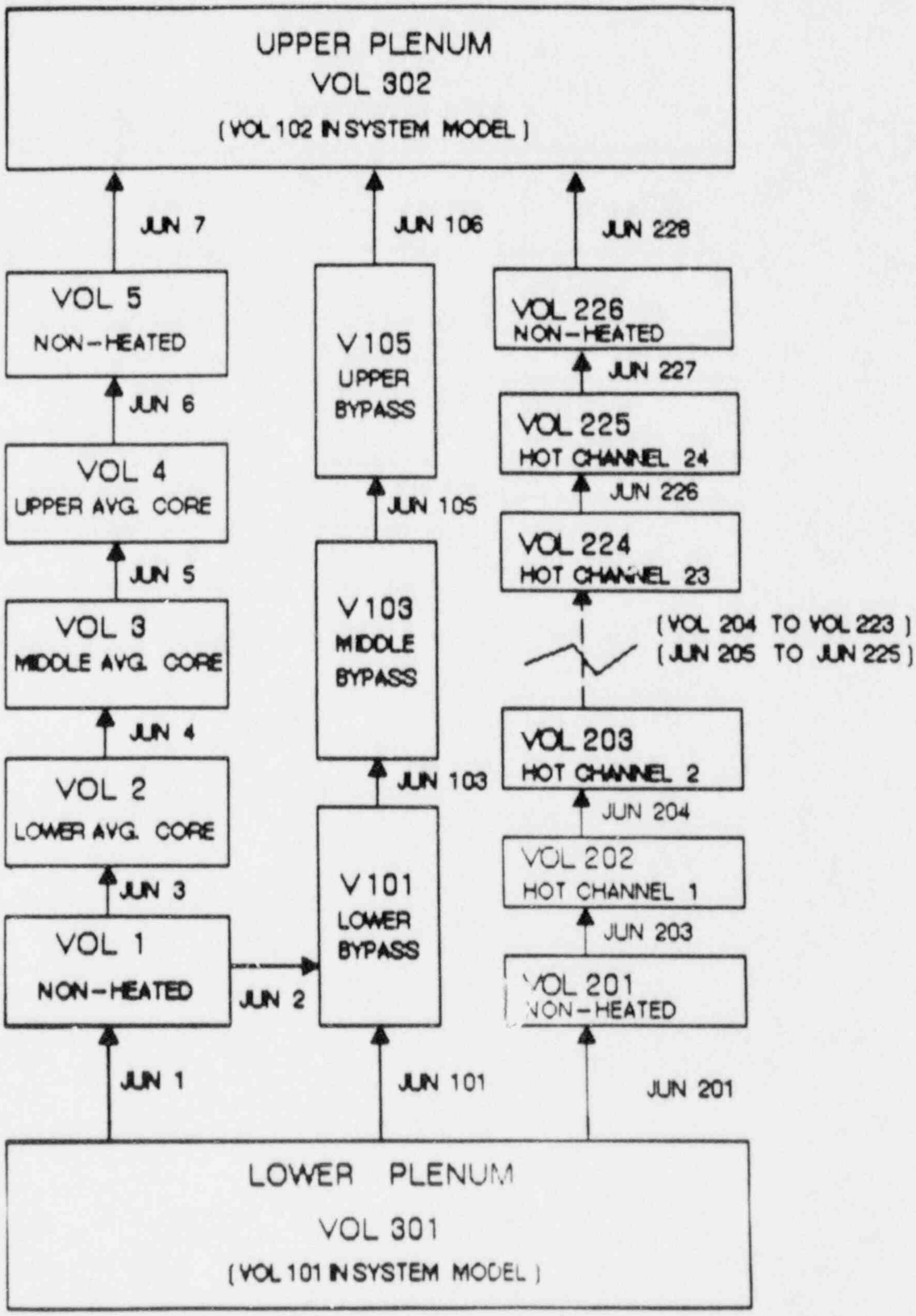

Figure 1 – Basic Hot Channel Model

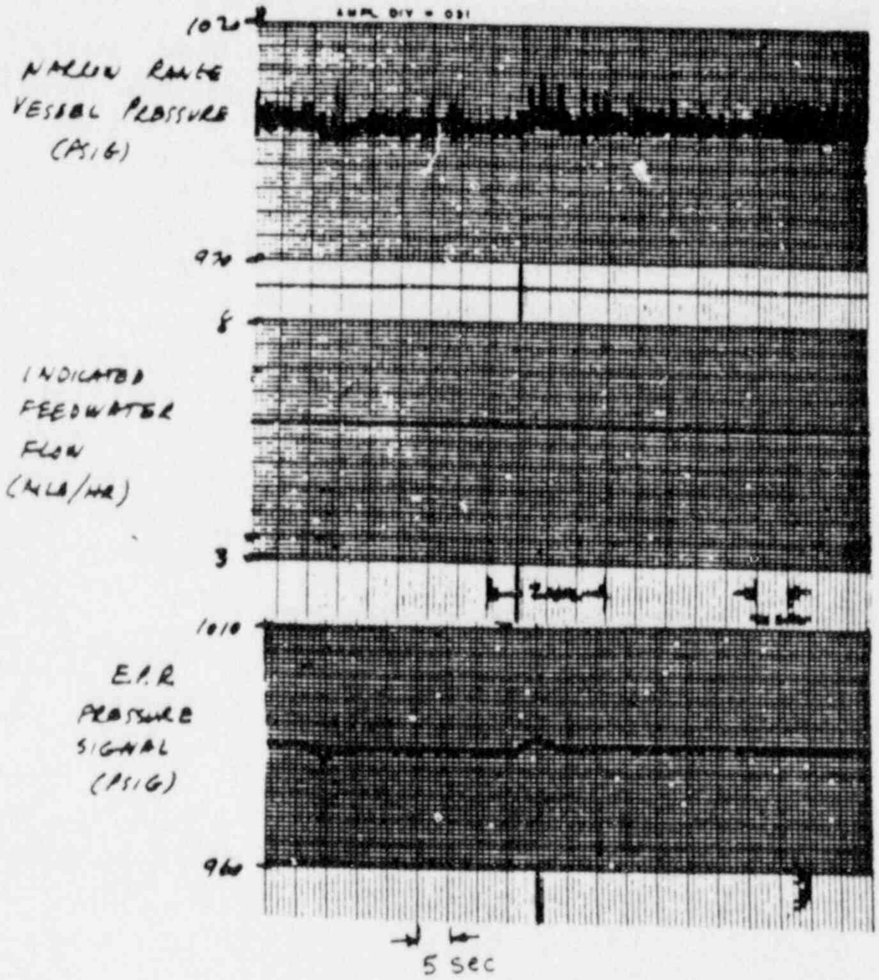

Figure 2 - Bypass Valve Test

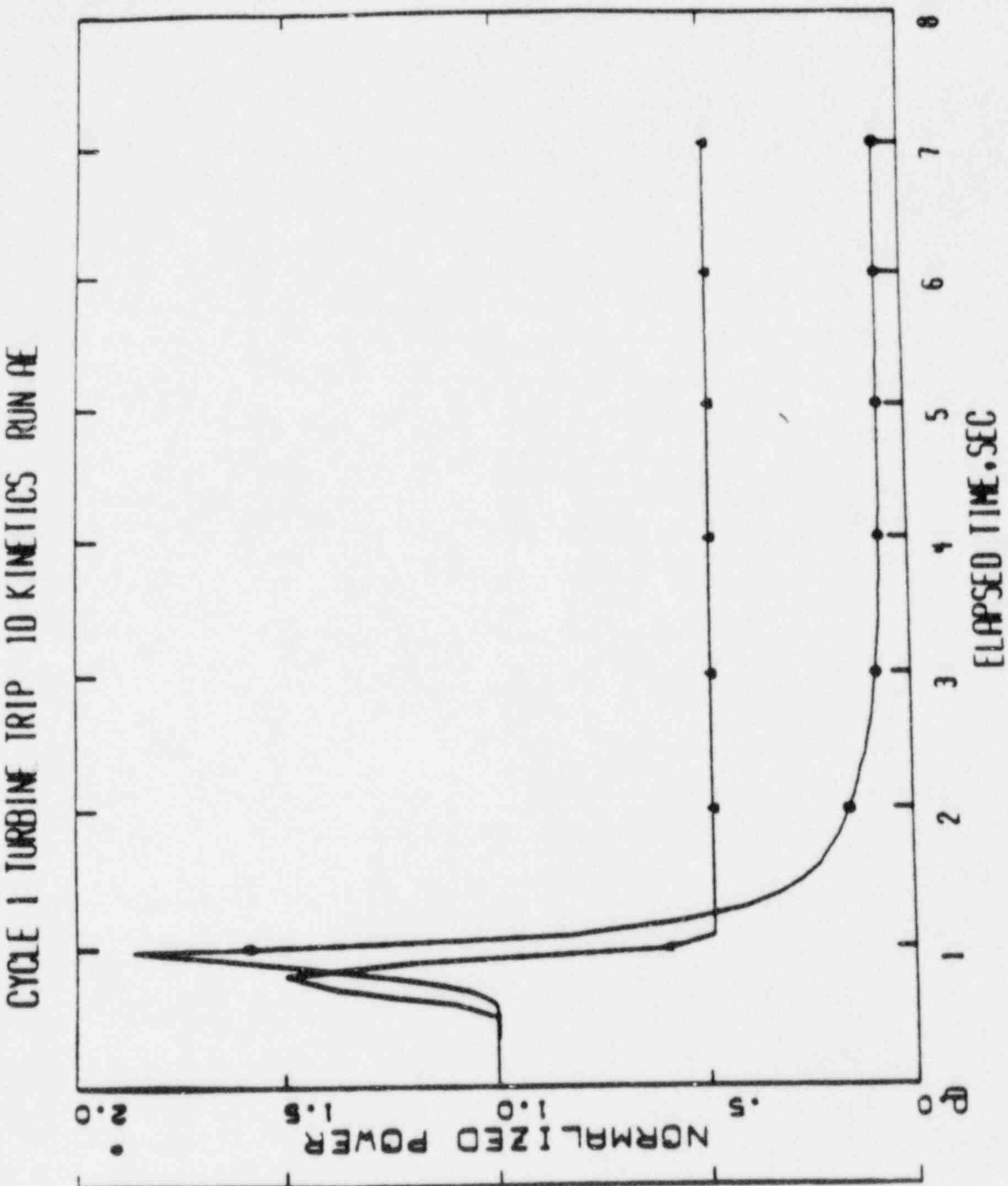
CYCLE 1 TURBINE TRIP 1D KINETICS RUN AE
NORMALIZED POWER
PLANT DATA
ELAPSED TIME,SEC
0.0
.5
1.0
1.5
2.0
0
1
2
3
4
5
6
7
8

Figure 3

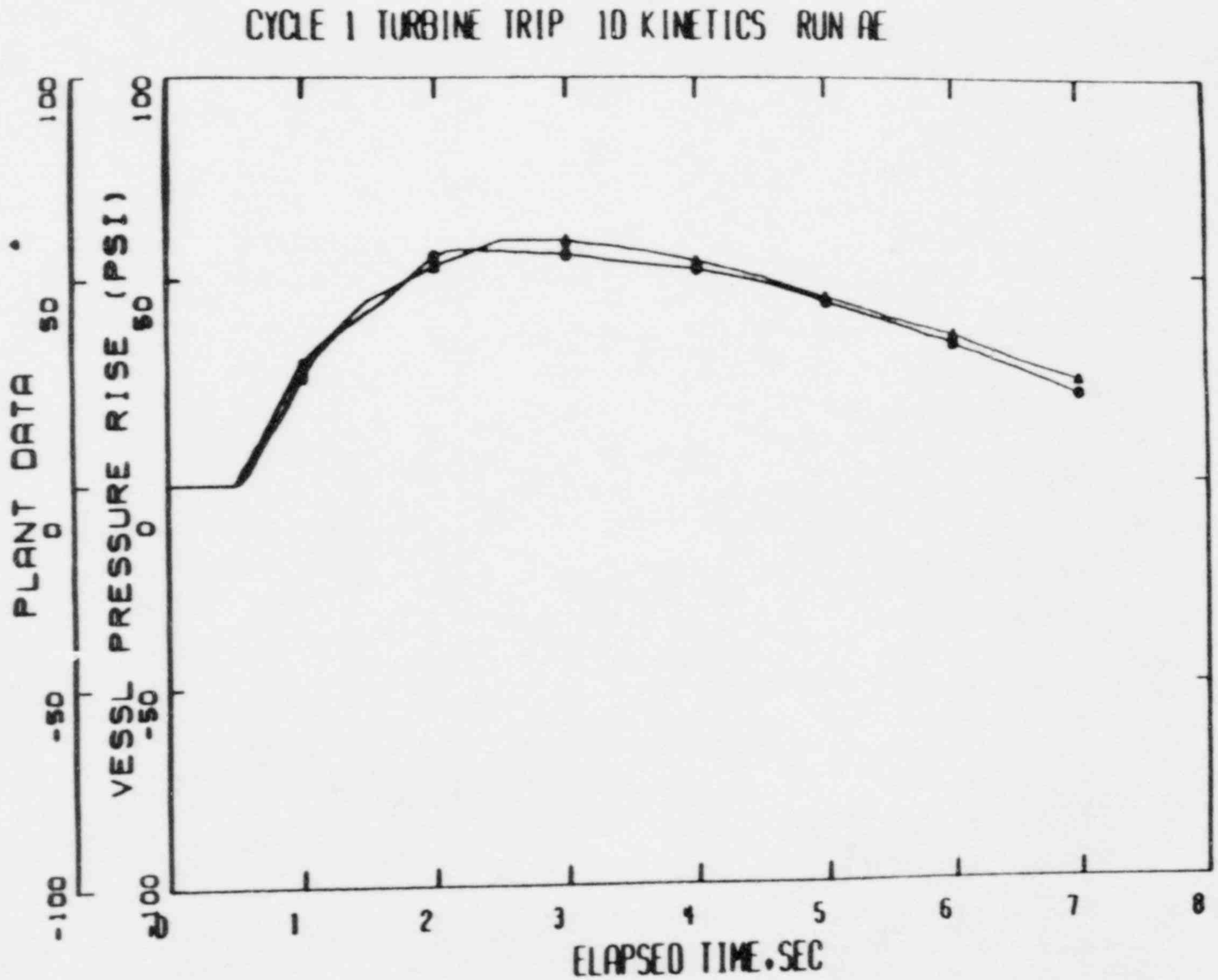
CYCLE 1 TURBINE TRIP 1D KINETICS RUN AE
PLANT DATA •
VESSL PRESSURE RISE (PSI)
100
50
0
-50
-100
0
1
2
3
4
5
6
7
8
ELAPSED TIME, SEC

Figure 4