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O. W. DIXON, JR.
VICE PRESIDENT
NUCLEAR OPERATIONS

August 8, 1983

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Virgil C. Summer Nuclear Station
Docket No. 50/395
Operating License No. NPF-12
Dropped Rod Methodology
License Condition 2.C.22

Dear Mr. Denton:

The Virgil C. Summer Nuclear Station Operating License Condition 2.C.22 requires that for operations above 90% of full power, the reactor shall be controlled manually or the D bank control rods shall be out greater than 215 steps until written approval is received from the NRC. By letter dated March 31, 1983, from C. O. Thomas (NRC) to E. P. Rahe (Westinghouse), the NRC approved the Westinghouse generic Dropped Rod Methodology.

Westinghouse has performed a plant specific analysis for the Virgil C. Summer Nuclear Station, Cycle 1, utilizing the NRC approved methodology. The results of the analysis indicate that the DNB design basis is met. Based on this evaluation, South Carolina Electric and Gas Company (SCE&G) has concluded that the interim restrictions for rod control are no longer required for Cycle 1. Attached are marked-up FSAR pages reflecting the new analysis.

By copy of this letter to Mr. James P. O'Reilly, SCE&G considers this letter the final report on the significant deficiency concerning the dropped rod analysis first reported to Region II on November 19, 1979.

We request your expeditious concurrence in our position on this item in order that the restriction on rod control operation can be removed. If you have any questions, please let us know.

Very truly yours,

O. W. Dixon, Jr.

B001
1/1

NEC:OWD/fjc
cc: (See Page #2)

cc: V. C. Summer
T. C. Nichols, Jr./O. W. Dixon, Jr.
E. H. Crews, Jr.
E. C. Roberts
H. N. Cyrus
J. P. O'Reilly
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C. L. Ligon (NSRC)
G. J. Braddick
J. C. Miller
J. L. Skolds
J. B. Knotts, Jr.
NPCF
File (Lic./Eng.)

4. For reactivity insertion rates less than $\sim 3 \times 10^{-5}$ δK/sec, the rise in the reactor coolant temperature is sufficiently high so that the steam generator safety valve setpoint is reached prior to trip. Opening of these valves, which act as an additional heat load of the reactor coolant system, sharply decreases the rate of rise of reactor coolant system average temperature. This decrease in rate of rise of the average coolant system temperature during the transient is accentuated by the lead-lag compensation causing the overtemperature ΔT trip setpoint to be reached later with resulting lower minimum DNBRs.

For transients initiated from higher power levels (for example, see Figure 15.2-8) this effect, described in item 4 above, which results in the sharp peak in minimum DNBR at $\sim 3 \times 10^{-5}$ δK/sec, does not occur since the steam generator safety valves are never actuated prior to trip.

Figures 15.2-8, 15.2-9 and 15.2-10 illustrate minimum DNBR calculated for minimum and maximum reactivity feedback.

15.2.2.3 Conclusions

The high neutron flux and overtemperature ΔT trip channels provide adequate protection over the entire range of possible reactivity insertion rates, i.e., the minimum value of DNBR is always larger than 1.30.

15.2.3 ROD CLUSTER CONTROL ASSEMBLY MISALIGNMENT

15.2.3.1 Identification of Causes and Accident Description

Rod cluster control assembly (RCCA) misalignment accidents include:

~~1. A dropped assembly;~~

1. One or more dropped RCCAs within the same group;
2. A dropped RCCA bank;
3. Statically misaligned RCCA.

2. A dropped assembly bank;

3. Statically misaligned assembly (see Table 15.2-2).

Each RCCA has a position indicator channel which displays position of the assembly. The displays of assembly positions are grouped for the operator's convenience. Fully inserted assemblies are further indicated by a rod bottom signal, which actuates a local alarm and a control room annunciator. Group demand position is also indicated. The assemblies are always moved in preselected banks and the banks are always moved in the same preselected sequence.

A dropped ~~assembly~~ RCCA or ~~assembly banks are~~ RCCA bank is detected by:

1. Sudden drop in the core power level as seen by the nuclear instrumentation system;

2. Asymmetric power distribution as seen on excore neutron detectors or core exit thermocouples;

3. Rod at bottom signal;

4. Rod deviation alarm;

5. Rod position indication.

Misaligned assemblies are detected by:

1. Assymetric power distribution as seen on excore neutron detectors or core exit thermocouples;

2. Rod deviation alarm;

3. Rod position indicators.

The resolution of the rod position indicator channel is ±5 percent of span (±7.2 inches). Deviation of any assembly from its group by twice this distance (10 percent of span, or 14.4 inches) will not cause power distributions worse than the design limits. The deviation alarm alerts the operator to rod deviation with respect to the group position in excess of five percent of span. If the rod deviation alarm is not operable, the operator is required to take action as required by the Technical Specifications.

If one or more rod position indicator channels should be out of service, detailed operating instructions shall be followed to assure the alignment of the nonindicated assemblies. The operator is also required to take action as required by the Technical Specifications. The operating instructions require selected pairs of core exit thermocouples to be monitored in a prescribed time sequence and following significant motion of the nonindicated assemblies. The operating instructions also call for the use of moveable incore neutron detectors to confirm core exit thermocouple indication of assembly misalignment.

15.2.3.2 Analysis of Effects and Consequences

15.2.3.2.1 Method of Analysis [See Insert A]

~~Steady-state power distributions are analyzed for this event using the TURTLE[8] Code. The peaking factors calculated by TURTLE are then used by the THINC Code to calculate the DNBR. For the transient response to a dropped RCCA or RCCA bank the LOFTRAN[7] Code is used. The code simulates the neutron kinetics, reactor coolant system, pressurizer, pressurizer relief and safety valves, pressurizer spray, steam generator, and steam generator safety valves. The code computes pertinent plant variables including temperatures, pressures, and power level.~~

15.2.3.2.1 Method of Analysis

Insert A

1. One or more dropped RCCAs from the same group.

For evaluation of the dropped RCCA event, the transient system response is calculated using the LOFTRAN code. The code simulates the neutron kinetics, Reactor Coolant System, pressurizer, pressurizer relief and safety valves, pressurizer spray, steam generator, and steam generator safety valves. The code computes pertinent plant variables including temperatures, pressures, and power level.

Statepoints are calculated and nuclear models are used to obtain a hot channel factor consistent with the primary system conditions and reactor power. By incorporating the primary conditions from the transient and the hot channel factor from the nuclear analysis, the DNB design basis is shown to be met using the THINC code. The transient response, nuclear peaking factor analysis, and DNB design basis confirmation are performed in accordance with the methodology described in Reference 13.

2. Statically Misaligned RCCA

Steady state power distribution are analyzed using the computer codes as described in Table 4.1-2. The peaking factors are then used as input to the THINC code to calculate the DNBR.

15.2.3.2.2 Results [See Insert B]

A dropped RCCA typically results in a reactivity insertion of -150 pcm. Analyses have shown that with the core power distribution which exists following the drop of a single RCCA, the reactor may be returned to full power with the full power reactor coolant system temperature (plus measurement and control errors) without the DNBR going below 1.30. This is verified by the results in Table 15.2-2.

Extensive analyses were performed to show that with automatic rod control the minimum DNBR occurs near the end of the transient when the reactor coolant system has essentially returned to its initial steady-state equilibrium conditions. Without automatic rod control, the system will return to a new equilibrium condition at a reduced primary temperature as a result of the moderator reactivity feedback. As typical of a PWR uncontrolled response, the return to power is monotonic and therefore power overshoot is not a concern for this case.

A power overshoot after a dropped RCCA incident can only result from the action of the automatic rod controller. For a given PWR system, the power overshoot is essentially a function of the rod controller characteristics. Large power overshoots can result if the rod controller is designed to restore primary system coolant temperature or secondary system steam pressure without regard for the core power level. The Westinghouse design uses a dual controller which limits the power overshoot. The important feature of the Westinghouse rod controller is that it terminates rod withdrawal well before the primary coolant average temperature is restored to an equilibrium condition. This not only minimizes the power overshoot but also ensures extra margin to DNB.

Sensitivity studies have confirmed that the maximum power overshoot occurs for the following conditions:

1. Minimum moderator reactivity feedback corresponding to beginning of core life conditions.

2. Maximum reactivity worth of the control bank.

Figure 15.2-11 illustrates the transient for the following limiting conditions:

1. Initial Power: 102 percent of rated power

2. Moderator Reactivity Coefficient: Least Negative

3. Control Bank Reactivity Worth: 12 pcm/step

4. Dropped RCCA Reactivity Worth: 250 pcm

The initial reactor coolant system temperature was assumed at its maximum value and the initial reactor coolant system pressure at its minimum value consistent with steady-state full power operation. See Section 15.1.2.2 for a discussion of initial conditions. The selection of a value of -250 pcm for the maximum reactivity insertion is a conservatively large value for the worth of a single dropped rod. As a result of a dropped rod, the nuclear power will decrease and the decrease will be sufficient to be detected by the power range negative neutron flux rate trip circuitry and trip the plant before the reactor can return to high power. The analysis was performed only to determine the limiting DNB conditions during the transient, thus it is independent of power distribution. The DNBR was computed along the transient assuming constant design hot channel factors to illustrate that limiting DNB conditions occur at the end of the transient. Therefore, only final equilibrium conditions need to be analyzed with the penalty associated for a dropped RCCA condition as shown in Table 15.2-2.

A dropped RCCA group typically results in a reactivity insertion of -1200 pcm which will be detected by the power range negative neutron flux rate trip circuitry. The reactor is tripped within approximately 2.5 seconds following the drop of a RCCA. The core is not adversely affected during this period, since power is decreasing rapidly.

The most severe misalignment situations with respect to DNBR at significant power levels arise from cases in which bank D is fully inserted with one RCCA fully withdrawn; a 12 foot misalignment error. Multiple independent alarms, including a bank insertion limit alarm, alert the operator well before the postulated conditions are approached. The bank can be inserted to its insertion limit with any one assembly fully withdrawn without the DNBR falling below 1.30.

The insertion limits in the Technical Specifications may vary from time to time depending on a number of limiting criteria. It is preferable, therefore, to analyze the misaligned RCCA case at full power for a position of the control bank as deeply inserted as the criteria on minimum DNBR and power peaking factor will allow. The full power insertion limits on control bank D must then be chosen to be above that position and will usually be dictated by other criteria. Detailed results will vary from cycle to cycle depending on fuel arrangements.

For Case I shown in Table 15.2-2 with bank D inserted to its full power insertion limit and one RCCA fully withdrawn, DNBR does not fall below 1.30. This case was analyzed at 102 percent of full power with the increased radial peaking factor associated with the misaligned RCCA.

DNB calculations have not been performed specifically for assemblies missing from other banks, however, power shape calculations have been done as required for the RCCA ejection analysis. Inspection of the power shapes shows that the DNB and peak kW/ft situation is less severe than the group D case discussed above assuming insertion limits on the other groups equivalent to a group D full-in insertion limit.

15.2.3.2.2 Results

Insert B

1 ~~2~~. One or more Dropped RCCAs

Single or multiple dropped RCCAs within the same group result in a negative reactivity insertion which may be detected by the power range negative neutron flux rate trip circuitry. If detected, the reactor is tripped within approximately 2.5 seconds following the drop of the RCCAs. The core is not adversely affected during this period, since power is decreasing rapidly. Following reactor trip, normal shutdown procedures are followed. The operator may manually retrieve the RCCA by following approved operating procedures.

For those dropped RCCAs which do not result in a reactor trip, power may be reestablished either by reactivity feedback or control bank withdrawal. Following a dropped rod event in manual rod control, the plant will establish a new equilibrium condition. ~~The equilibrium process~~ without control system interaction is

The power increase

monotonic, thus removing power overshoot as a concern, and establishing the automatic rod control mode of operation as the limiting case.

For a dropped RCCA event in the automatic rod control mode, the Rod Control System detects the drop in power and initiates control bank withdrawal. Power overshoot may occur due to this action by the automatic rod controller after which the control system will insert the control bank to restore nominal power. Figure 15.2-11 shows a typical transient response to a dropped RCCA (or RCCAs) in automatic control. Uncertainties in the initial condition are included in the DNB evaluation as described in Reference 13. In all cases, the minimum DNBR remains above the limit value, 1.30.

2 ~~f~~. Dropped RCCA Bank

A dropped RCCA bank typically results in a reactivity insertion greater than 500 pcm which will be detected by the power range negative neutron flux rate trip circuitry. The reactor is tripped within approximately 2.5 seconds following the drop of a RCCA Bank. The core is not adversely affected during this period, since power is decreasing rapidly. Following reactor trip, normal shutdown procedures are followed to further cool down the plant. Any action required of the operator to maintain the plant in a stabilized condition will be in a time frame in excess of ten minutes following the incident.

3 ~~g~~. Statically Misaligned RCCA

The most severe misalignment situations with respect to DNBR at significant power levels arise from cases in which one RCCA is fully inserted, or where bank D is fully inserted with one RCCA fully withdrawn. Multiple independent alarms, including a bank insertion limit alarm, alert the operator

well before the postulated conditions are approached. The bank can be inserted to its insertion limit with any one assembly fully withdrawn without the DNBR falling below the limit value.

The insertion limits in the technical specifications may vary from time to time depending on a number of limiting criteria. It is preferable, therefore, to analyze the misaligned RCCA case at full power for a position of the control bank as deeply inserted as the criteria on minimum DNBR and power peaking factor will allow. The full power insertion limits on control bank D must then be chosen to be above that position and will usually be dictated by other criteria. Detailed results will vary from cycle to cycle depending on fuel arrangements.

For this RCCA misalignment, with bank D inserted to its full power insertion limit and one RCCA fully withdrawn, DNBR does not fall below the limit value. This case is analyzed assuming the initial reactor power, pressure, and RCS temperatures are at their nominal values including uncertainties (as given in Table 15.1-2), but with the increased radial peaking factor associated with the misaligned RCCA.

DNB calculations have not been performed specifically for RCCAs missing from other banks; however, power shape calculations have been done as required for the RCCA ejection analysis. Inspection of the power shapes shows that the DNB and peak kw/ft situation is less severe than the bank D case discussed above assuming insertion limits on the other banks equivalent to a bank D full-in insertion limit.

For RCCA misalignments with one RCCA fully inserted, the DNBR does not fall below the limit value. This case is analyzed assuming the initial reactor power, pressure, and RCS temperatures are at their nominal values, including uncertainties (as given in Table 15.1-2) but with the increased radial peaking factor associated with the misaligned RCCA.

DNB does not occur for the RCCA misalignment incident and thus the ability of the primary coolant to remove heat from the fuel rod is not reduced. The peak fuel temperature corresponds to a linear heat generation rate based on the radial peaking factor penalty associated with the misaligned RCCA and the design axial power distribution. The resulting linear heat generation is well below that which would cause fuel melting.

Following the identification of a RCCA group misalignment condition by the operator, the operator is required to take action as required by the plant technical specifications and operating instructions.

15.2.3.3 Conclusions [See Insert C]

It is shown that in all cases of dropped single RCCA, the DNBR remains greater than 1.30 at power and, consequently, a dropped single RCCA does not cause core damage.

For all cases of dropped banks, the reactor is tripped by the power range negative neutron flux rate trip and consequently dropped banks do not cause core damage.

For all cases of any bank inserted to its rod insertion limits with any single RCCA in that bank fully withdrawn, the DNBR remains greater than 1.30.

15.2.4 UNCONTROLLED BORON DILUTION

15.2.4.1 Identification of Causes and Accident Description

Reactivity can be added to the core by feeding primary grade water into the reactor coolant system (RCS) via the reactor makeup portion of the chemical and volume control system (CVCS). Boron dilution is a manual operation under strict administrative controls with procedures calling for a limit on the rate and duration of dilution. A boric acid blend system is provided to permit the operator to match the boron concentration of reactor coolant makeup water during normal charging to that in the RCS. The CVCS is designed to limit, even under various postulated failure modes, the potential rate of dilution to a value which, after indication through alarms and instrumentation, provides the operator sufficient time to correct the situation in a safe and orderly manner.

The opening of the primary water makeup control valve provides makeup to the RCS which can dilute the reactor coolant. Inadvertent dilution from this source can be readily terminated by closing the control

15.2.3.3 <u>Conclusions</u>

Insert C

For cases of dropped RCCAs or dropped banks, for which the reactor is tripped by the power range negative neutron flux rate trip, there is no reduction in the margin to core thermal limits, and consequently the DNB design basis is met. It is shown for all cases which do not result in reactor trip that the DNBR remains greater than the limit value and, therefore, the DNB design is met.

For all cases of any RCCA fully inserted, or bank D inserted to its rod insertion limits with any single RCCA in that bank fully withdrawn (static misalignment), the DNBR remains greater than the limit value.

10. Geets, J. M., "MARVEL - A Digital Computer Code for Transient Analysis of a Multiloop PWR System," WCAP-7909, June, 1972.

11. Mangan, M. A., "Overpressure Protection for Westinghouse Pressurized Water Reactors," WCAP-7769, October, 1971.

12. Geets, J. M. and Salvatori, R., "Long Term Transient Analysis Program for PWR's (BLKOUT Code)," WCAP-7898, June, 1972.

13. Morita, T., et. al., "Dropped Rod Methodology for Negative Flux Rate Trip Plants" WCAP-10297-P-A (Proprietary) and WCAP-10298-A (Non-Proprietary), June, 1983.

TABLE 15.2-2

MINIMUM CALCULATED DNBR FOR CASES OF ROD CLUSTER CONTROL ASSEMBLY MISALIGNMENT AND DROPPED ROD CLUSTER CONTROL ASSEMBLY

Cases Analyzed	Radial Power Peaking Factor $(F_{\Delta H})$ (1)	Minimum DNBR
Bank D at insertion limit, E-2 fully withdrawn (Rod Cluster Control Assembly Misalignment)	1.69	> 1.3
Dropped Rod Cluster Control Assembly G-9	1.51	> 1.3
Dropped Rod Cluster Control Assembly F-10	1.59	> 1.3
Dropped Rod Cluster Control Assembly E-11	1.56	> 1.3
Dropped Rod Cluster Control Assembly H-10	1.59	> 1.3
Dropped Rod Cluster Control Assembly H-14	1.55	> 1.3

(1) Values include 15% uncertainty allowance in $F_{\Delta H}$.

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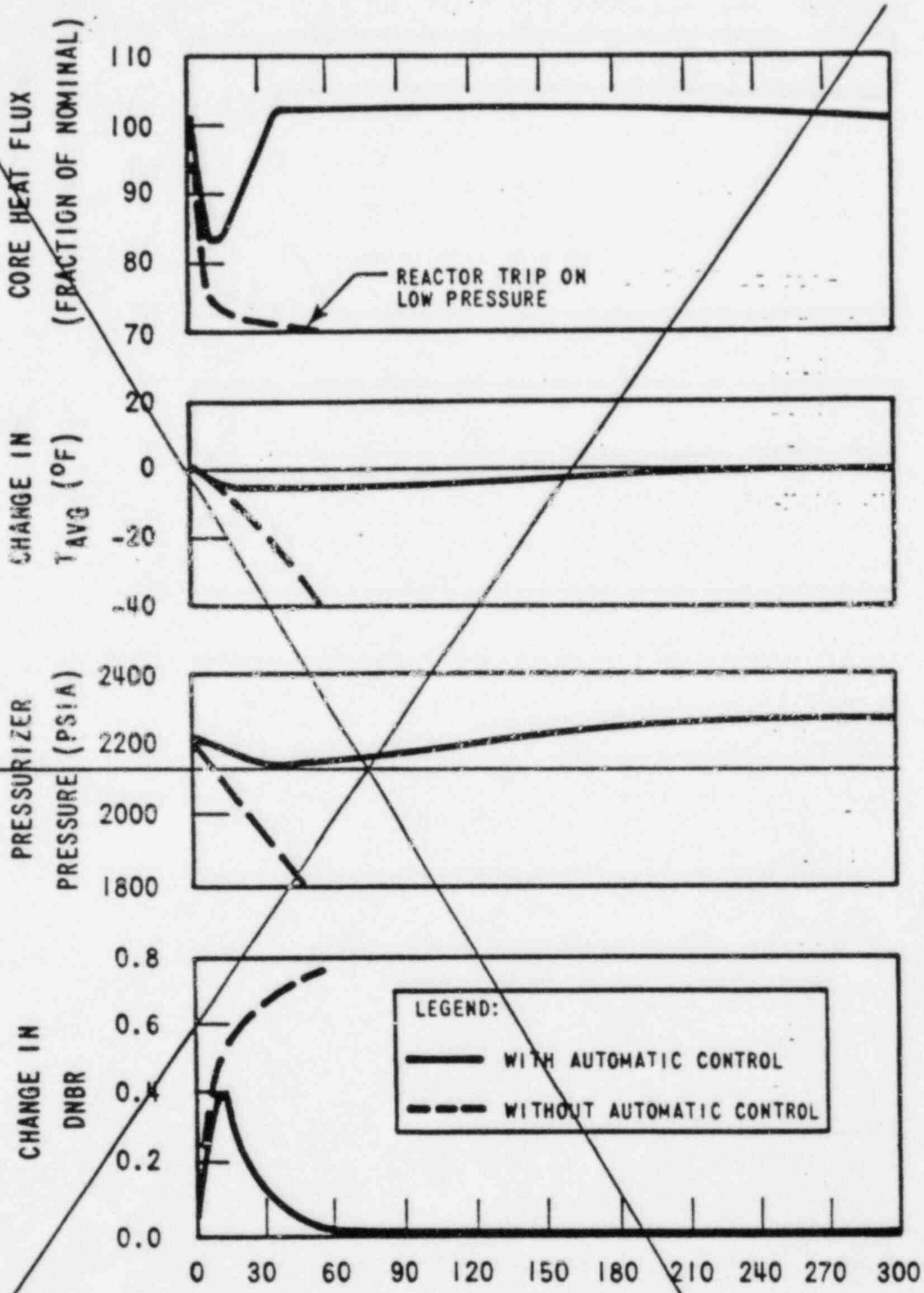

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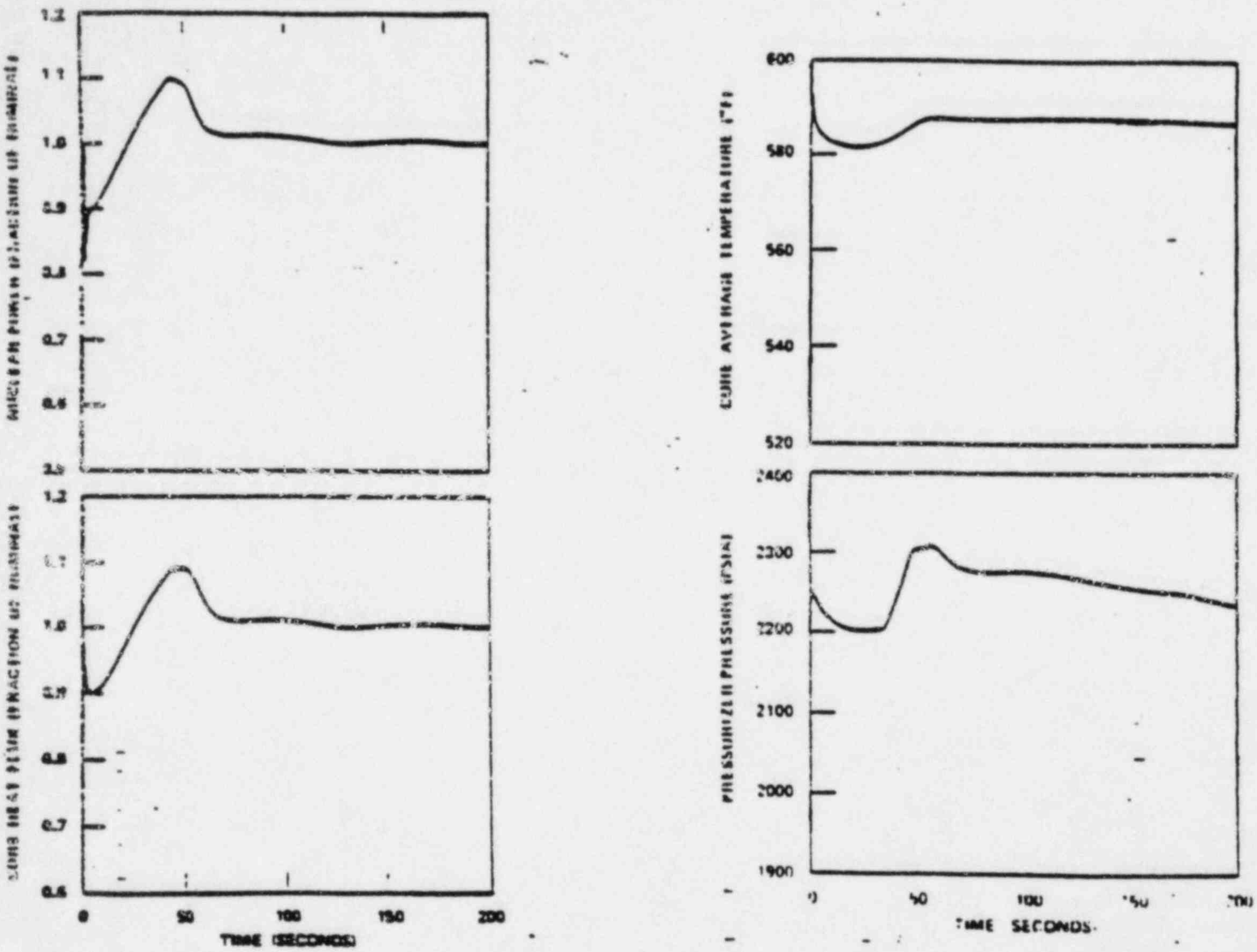
VIRGIL C. SUMMER NUCLEAR STATI

Transient Response to Droppe
Rod Cluster Control Assembl

Figure 15.2-11



Insert Figure

Transient Response to Dropped Rod Cluster Control Assembly

Figure 15.2-11