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Docket No. 50-344

Mr. Bart D. Withers
Vice President Nuclear
Portland General Electric Company
121 S. W. Salmon Street
Portland, Oregon 97004

Dear Mr. Withers:

This is a follow-on to our letter of June 8, 1982 which responded to your letter of April 30, 1982 on the subject of interim operating restrictions for the rod control system at the Trojan Nuclear Plant.

The Westinghouse report dated January 20, 1982 has been reviewed an and found acceptable, subject to the conditions described in the attached evaluation, "Review of the Westinghouse Report - Dropped Rod Methodology for Negative Flux Rate Trip Plants."

This report applies to Trojan (among others) and indicates that the interim restrictions on the rod control system can be removed for a given reactor cycle for which the required analysis has been performed with acceptable results. We note that the required technical specification for Power Range Neutron Flux (High Negative Rate) of 5% RTP with time constant of 2 seconds is already in place (Table 2.2-1, item 4, p.2-5). The restrictions should remain in effect, however, for any cycle in which an acceptable analysis has not been performed. The analytical methods of the Westinghouse report are therefore an acceptable substitute for the operating restrictions.

Please contact us if you have any questions concerning this matter.

Sincerely,

Original signed by

Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

Enclosure:
Review of W Report

cc: w/enclosure
See next page

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SURNAME	PKreutzer	CTrammell:dd	RAClark				
DATE	3/9/83	3/9/83	3/9/83				

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REVIEW OF THE WESTINGHOUSE REPORT
"DROPPED ROD METHODOLOGY FOR NEGATIVE FLUX RATE TRIP PLANTS"

Introduction

When operating at power, a dropped (withdrawn) control rod, single or multiple, in a PWR may result in a transient leading to reduced margins to fuel design limits and in particular to DNB limits. This would be a result of increased power distribution peaking factors with the inserted (dropped) rods and a possible "return to power" transient, produced by feedback or automatic control, which might, depending on the control system, include a power level exceeding the initial level. A dropped rod (rods) transient resulting from a single failure and exceeding DNB limits is considered unacceptable.

For Westinghouse reactors the dropped rod event will be terminated by turbine runback for the older plants. For the newer plants (see Table 1 at end of report) the negative flux rate trip system will sense the initial rapidly decreasing neutron flux (as a negative rate) and trip the scram system (thus ending the event) for many of the dropped rod events. For some events, however, the flux decrease rate may be insufficient for a trip. For these events the analysis has for many years concluded that for Westinghouse plants the peaking factors and transient powers resulting from single failures do not result in exceeding limits. A major factor in the analysis has been zero or very limited transient overshoot above the initial power level.

However, in 1979 Westinghouse notified the NRC (letter from T. Anderson, Westinghouse, to J. Davis, NRC, March 30, 1979) under 10CFR50.59 of the potential for the dropped rod event in some plants to lead to lower DNB ratios than had been previously reported. The primary reason for the potential change in analysis results was the recognition that when operating with automatic control the control system, for three loop plants (because of their particular control detector configuration), could be reading a lower than average nuclear power level signal and could then cause a larger transient power overshoot than had been considered. The lower control signal and transient overshoot occurs if the dropped rod (which lowers the flux in its vicinity) is near the excore neutron detector used for control. It was subsequently also recognized (letter from T. Anderson, Westinghouse, to V. Stello, NRC, November 15, 1979) that a single failure in the controller circuits of two and four loop plants could cause a similar problem. Thus the problem could occur in any Westinghouse reactor with negative flux rate trip (listed in Table 1) for events in which scram did not occur and for which the reactor is in automatic control. (In manual control the power rise from feedback is insufficient to cause a problem.)

The problem can occur only in the automatic mode of control operation and when there is sufficient control rod bank reactivity worth inserted as an initial condition for the event to allow the automatic control to withdraw the bank and raise the power into an overshoot condition. Thus Westinghouse proposed an interim solution to the potential problem, of requiring either manual control or minimal rod insertion (D bank control rods beyond 215 steps) above 90 percent power (letter from T. Anderson, Westinghouse, to A. Schwencer, NRC, November 28, 1979). The staff review found the proposal satisfactory and relevant Boards and Utilities were notified of the problem and solution (e.g., see L Engle, Meeting Report, January 18, 1980, and memorandum from R. Mattson, NRC, to S. Varga, NRC, February 20, 1980). The plants listed in Table 1 have been (or would be) operating under these restrictions.

Westinghouse then proceeded to carry out a more detailed analysis of the problems and parameters of the event and has developed the method of analysis the staff has reviewed and which is described in this report. This analysis approach requires reactor specific calculations for each reactor and cycle to show that the parameters for the reactor are such that DNB limits will not be exceeded for the event.

As this report will discuss, the staff review has found the Westinghouse approach and analysis acceptable. This means that when the approved reactor specific analysis for a given reactor-cycle has been done and the limiting parameters determined and suitably compared to Technical Specification limits for the cycle, power operation may proceed without the 90 percent power insertion and automatic control limits presently required.

Westinghouse Analysis Model and Evaluation

The Westinghouse approach to the analysis of the event is partially generic and partially reactor-cycle specific. The problem is divided into two primary areas, (1) determination of which dropped rods will trip the negative flux rate scram system and thus require no further analysis and (2) the determination of the consequences of the transient for rods which may not cause a trip. The final product of part (2) is the determination of limiting initial condition peaking factors (to be compared to Technical Specifications) for which limiting transients will not exceed DNB limits. The part (1) analyses and results are generic. The part (2) analyses, parameters and results are partly generic (primarily parameters related to power distribution and chosen from bounds of many calculations) and partly reactor-cycle specific (primarily transient and DNB evaluation parameters). Westinghouse uses a combination of kinetic and static calculation techniques and approximations for these analyses.

There are two aspects of the event involving transient analysis and the neutron flux levels seen by the excore detectors. There is first the rapid flux decrease transient ("prompt drop" kinetic regime) caused by the dropping rods and occurring within two or three seconds. This transient and the response of several of the detectors used in the protection system determines if trip will occur. Then there is the flux increase transient (for the untripped event of interest, i.e., under automatic control) taking place over a much longer time interval (order of a minute) during which overshoot may occur as influenced by the flux seen by the excore detector used by the control system.

For both of these aspects flux distributions, produced by the dropped rods and as seen by the excore detectors, are required since they strongly influence the transient response. Westinghouse, using static methods, has produced calculations of flux distributions from a wide variety of combinations of dropped rods for two, three and four loop reactors. These are taken from various combinations from the same control rod group within a rod bank which could drop from a single failure. Correlations are used to translate from the core edge power densities to the excore detectors. The feedbacks used in the static calculations are appropriate to the transient conditions to be examined, i.e., fast or slow transients.

For the part (1) analysis of which rods will trip the negative flux rate scram system, Westinghouse developed from these distribution calculations a relation between dropped rod reactivity worth and the flux, specified in terms of relative tilt (among the excores), seen by the appropriate excore detectors, consistent with the two out of four (plus a failure) logic of the scram system. The rod worths and tilts were than used in calculations of the rapid initial transients (using conservative parameters, e.g., maximized delayed neutron fraction to give minimum flux drop rate during the prompt drop time frame), which were in turn input into a rate trip system simulator program.

The result of this analysis is a conservative bounding correlation of the maximum rod reactivity worth which may possibly not result in a negative flux rate trip (assuming a nominal system setpoint of 5 percent reactor total power (RTP) with a time constant of 2 seconds; with uncertainty, an analysis value of 6.9 percent RTP/2 seconds). Rod worths equal to and less than this value are then examined in part (2) of the analysis, even though many of these drop configurations would be expected to result in trip. These limiting worths are dependent on the control rod material (i.e., Ag-In-Cd vs B_4C) via drop velocity (and corresponding Technical Specification scram time) and this dependence was included in the analysis.

The review of part (1) has indicated that acceptable selections, methods and parameters have been used to determine:

1. Rod combinations which will drop with a single failure (from one group from a bank).
2. Core neutron flux patterns with dropped rods (static calculations are suitably conservative for the prompt drop time frame, with the feedback used, and for the flux patterns affecting the limiting excore detector in the trip system).
3. Transfer of flux from the core to the excore detectors to determine tilts (correlations of core edge flux to detector response).
4. Initial transient flux changes (acceptable feedback and delayed neutron fraction).
5. Minimal responding detector in the rate trip system (two out of four system with one failure).
6. Conservative bounding for dropped rods which will trip the rate system (given the chosen trip setpoint).

It should be noted that while there have been tests of the negative flux rate scram for dropped rods in reactor startup test programs, in which there generally have always been scrams, as expected, these tests have not been sufficient to provide the boundaries produced in this part (1) analysis. This is partially because the analysis is intended to be a conservative bound and it is expected that most configurations less than the bound would scram. But it is also because the required detector in a two out of four system (with one failure) was not adequately tested. Two tests on Westinghouse reactors are expected in 1983, however, which will properly test this detector trip. These tests will not provide bounds for a comparison with the analytical bounds, but they will be examined by the staff for any indications that the part (1) analysis is non-conservative.

In part (2) of the Westinghouse approach the transient, and its consequences, which result when no trip occurs is examined. Rather than attempting (dropped) rod specific configured three dimensional neutronic-system calculations, Westinghouse uses a standard systems transient (including control systems) code using point kinetics for the core neutronics with a range of rod reactivity worths as a parameter, and uses separately generated, generically bounding, relations among reactor state conditions and peaking factors to relate power density aspects of initial and maximum states. The latter are done with static calculations. The process involves

1. The selection of relevant core and system initial state and transient kinetic parameters. These parameters are plant, cycle and burnup specific. The values used are in some cases nominal, discussed below for DNB evaluation, but otherwise are conservative as normally used in SAR transient analyses. The event unique parameters include dropped rod reactivity worth (relevant to the semi-equilibrium state of interest to transient overshoot and covering a range up to the value found in part (1)), inserted control bank reactivity worth (determined from Technical Specification bank insertion limits and a generically derived conservative augmentation value to account for extremes in worth), and a generic lower bound on the excore tilt parameter to be used in the ("worst detector") control system simulation (determined as discussed in part (1)), each selected to give maximum overshoot. It is concluded that the selection process is acceptable.

2. The reactor-cycle-burnup specific transient analysis of the power rise with automatic control (using the "worst detector") covering an appropriate range of dropped rod worth and times in cycle, and determining the reactor state points (temperature, pressure and power) at maximum overshoot for use in DNB analysis. This is a relatively slow transient with state parameters changing slowly at the peak. It is concluded that the method used, along with the parameter selection, is suitable for determining a maximum statepoint.

3. The determination of reactor specific DNB limit lines as a function of state parameters and compatible with design (and Technical Specification) radial and axial peaking. The determination process and the DNB correlations used are the same as those used for other

transient analyses, for a given reactor, except that Westinghouse has chosen to use the methods of the "Improved Thermal Design Procedure" (ITDP) both in reactors which use the methodology in all transient analyses and in those which have used the more standard worst case DNB analysis for including uncertainties in their SAR calculations. This procedure calls for the use of nominal values of a few select parameters in determining DNB conditions and the statistical combination of the uncertainties of these parameters to provide a correction factor to account for the uncertainties. Other parameters are used at normal bounding values. This method has been reviewed and approved by the staff and has been used and approved for a number of recent licensing actions. A limited subset of the parameters normally considered in ITDP is used. The uncertainties used have been presented and are acceptable. The combined uncertainty in this case is dominated by the $F_{\Delta H}$ uncertainty for which a conservative value is used. The resulting DNB limit lines are plant and cycle specific. A rod bow penalty, when required, is applied separately, as a function of burnup, in determining limiting parameters. The process of selection of the DNB limit lines is acceptable.

4. The determination of relevant peaking factors for the transient using generic bounding correlations among these and state parameters. In particular, these generic correlations are used to relate (conservatively) peak transient power densities to initial conditions for the transient. The correlations, which are a key element in part (2), were derived from calculations covering numerous plants and cycles and included two and three dimensional (static) neutronic calculations. These bounding correlations are generally quite conservative and the use of static calculations is reasonable for the purpose since the transient is slow for this aspect of the event and the relevent states are near equilibrium. The methods, results and application are acceptable.

5. The determination for a given set of initial conditions if the DNB limits are met at maximum transient conditions, or conversely, which initial conditions are required not to exceed limits. This is done using the parameters, transient calculation results, DNB limit lines, and correlations previously discussed. This is done over a range of burnups covering the specific cycle. The process is complete and satisfactory if over the cycle and for a complete range of rod worths (which might not trip) the initial conditions required not to exceed DNB limits are compatible with the Technical Specification values for the cycle. This comparison process is acceptable. Westinghouse has carried out this process for a number of representative plants and cycles, as described in the report, and the results were satisfactory.

In summary the part (2) analysis, done for each reactor-cycle, consists of transient analyses(as a function of dropped rod worth and burnup) using a system code with point kinetics and reactor specific parameters to get state parameters at a maximum state point (overshoot), DNB limit line determination using ITDP and plant specific parameters, translation via generic parameters from initial to maximum state power peaking, and a determination using the above results that initial conditions within design (Technical Specification) limits will lead to conditions within DNB limits. The review of the part (2) analysis has indicated that acceptable methods and parameters have been used in each segment and in overall combination. In particular (1) the selection of transient parameters is conservative, especially the bank worth and tilt magnitude for maximum overshoot, (2) the transient calculation with the standard system code, using point kinetics, is suitable for semi-equilibrium maximum state determination, and (3) when used in conjunction with the conservative correlations for relevant power peaking factors to determine maximum local conditions, the use of ITDP and the parameters used in its application are acceptable.

Conclusions

Westinghouse reactors with negative flux trip scram for the control rod drop event (reactors listed in Table 1) presently are required to operate at above 90 percent power with restrictions on control bank insertion (D beyond 215 steps) or automatic control (must be in manual) in order to mitigate the event. This resulted from the discovery that previous analyses neglected a possible control aspect of the event, and that previous analysis could not be modified simply to provide an adequate determination. Westinghouse has now produced a more comprehensive analytical process for the event in which it is demonstrated that if certain initial operating conditions are met the event will result either in a scram (and no problem) or will not exceed DNB limits. The staff has reviewed both aspects of this calculational process, the parameters proposed to be used in the calculations and the comparisons to be made, and has concluded that they provide an acceptable analysis procedure.

The Westinghouse analyses (via some parameters), results and comparisons are reactor and cycle specific and apply only for a negative flux rate nominal setpoint of 5 RTP/2 seconds. Thus any utility using this approach to remove existing operating restrictions must use this setpoint (to be noted in the Technical Specifications) and have the procedure performed for each cycle for each reactor (or develop and have approved an alternate method). Otherwise the restrictions on bank positions or automatic control must be in effect (for each of the reactors of Table 1). A further review by the staff (for each cycle) is not necessary, however, given the utility assertion that the analysis described by Westinghouse has been performed and the required comparisons have been made with favorable results.

Principal Contributor:

H. Richings, Core Performance Branch, NRR

TABLE 1

Prairie Island 1 and 2
Kewaunee
North Anna 1 and 2
Beaver Valley 1 and 2
Farley 1 and 2
Summer
Harris 1 and 2
Zion 1 and 2
Cook 1
Cook 2
Trojan
Salem 1 and 2
Sequoyah 1 and 2
Byron 1 and 2
Braidwood 1 and 2
McGuire 1 and 2
Catawba 1 and 2
Vogtle 1 and 2
Seabrook 1 and 2
Millstone 3
Marble Hill 1 and 2
Diablo Canyon 1 and 2
Calloway
Wolf Creek 1 and 2
Comanche Peak 1 and 2
South Texas 1 and 2
Watts Bar 1 and 2