DELETE

e. ~~Power range high negative neutron flux rate trip~~

~~This circuit trips the reactor when a sudden abnormal decrease in nuclear power occurs in two out of four power range channels. This trip provides protection against two or more dropped rods and is always active. Protection against one dropped rod is not required to prevent occurrence of DNB per Section 15.2.3.~~

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Figure 7.2-1, Sheet 2, shows the logic for all of the nuclear overpower and rate trips. Detailed functional descriptions of the equipment associated with these functions are given in References [2] and [15].

2. Core Thermal Overpower Trips

The specific trip functions generated are as follows:

a. Overtemperature ΔT trip

This trip protects the core against low DNBR and trips the reactor on two out of four coincidence with one set of temperature measurements per loop. The setpoint for this trip is continuously calculated by the Eagle-21 process protection circuitry for each loop by solving the following equation:

$$OT\Delta T \ \ \text{Setpoint} = \Delta T_0 \left[K_1 - K_2 \left(\frac{1 + \tau_1 s}{1 + \tau_2 s} \right) (T - T') + K_3 (P - P') - f_1(\Delta I) \right]$$

An overtemperature ΔT reactor trip occurs when

$$\Delta T \left(\frac{1 + \tau_4 s}{1 + \tau_5 s} \right) > OT\Delta T \ \ Setpoint$$

where:

ΔT	=	Measured temperature difference between hot and cold leg, °F
ΔT_o	=	Indicated loop ΔT at rated thermal power (RTP), °F
K_1	=	Reference trip setpoint
K_2	=	Penalty or benefit multiplier for deviation from indicated T_{avg}, /°F
K_3	=	Penalty or benefit multiplier for deviation from reference pressure, /psig
τ_1, τ_2	=	Lead/lag time constants for T_{avg} compensation, seconds
τ_4, τ_5	=	Lead/lag time constants for ΔT compensation, seconds
s	=	Laplace transform operator, sec^{-1}
T	=	Measured RCS average temperature (T_{avg}), °F
T'	=	Indicated loop T_{avg} at RTP, °F
P	=	Measured pressurizer pressure, psig
P'	=	Nominal RCS operating pressure, psig
$f_1(\Delta I)$	=	Power shaped penalty - function of the indicated difference between the top and bottom detectors of the power range neutron ion chambers.

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P PDR

15.1.4 Instrumentation Drift And Calorimetric Errors - Power Range Neutron Flux

The instrumentation drift and calorimetric errors used in establishing the power range high neutron flux setpoint are presented in Reference [22].

The calorimetric error is the error assumed in the determination of core thermal power as obtained from secondary plant measurements. The total ion chamber current (sum of the top and bottom sections) is calibrated (set equal) to this measured power on a periodic basis.

The secondary power is obtained from measurement of feedwater flow, feedwater inlet temperature to the steam generators and steam pressure. High accuracy instrumentation is provided for these measurements with accuracy tolerances much tighter than those which would be required to control feedwater flow.

15.1.5 Rod Cluster Control Assembly Insertion Characteristic

The rate of negative reactivity insertion following a reactor trip is a function of the acceleration of the rod cluster control assemblies and the variation in rod worth as a function of rod position. With respect to accident analyses, the critical parameter is the time of insertion up to the dashpot entry or approximately 85% of the rod cluster travel. The most limiting insertion time to dashpot entry used for accident analyses is 2.7 seconds. ~~For the dropped rod cluster control assembly analysis (Section 15.2.3), a rod insertion time of 3.3 seconds is assumed (consistent with Reference [21]).~~ The normalized rod cluster control assembly position versus time curve assumed in accident analyses is shown in Figure 15.1-2.

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Figure 15.1-3 shows the fraction of total negative reactivity insertion for a core where the axial distribution is skewed to the lower region of the core. An axial distribution which is skewed to the lower region of the core can arise from an unbalanced xenon distribution.

There is inherent conservatism in the use of this curve in that it is based on a skewed flux cases other than those associated with unbalanced xenon distributions, significant negative reactivity would have been inserted due to the more favorable axial distribution existing prior to trip.

The normalized rod cluster control assembly negative reactivity insertion versus time curve corresponding to an insertion time to dashpot entry of 2.7 seconds is shown in Figure 15.1-4. The curve shown in this figure was obtained from Figures 15.1-2 and 15.1-3. A total negative reactivity insertion following a trip of 4%$\Delta k/k$ is assumed in the transient analyses except where specifically noted otherwise. This assumption is conservative with respect to the calculated trip reactivity worth available as shown in Table 4.3-3.

7. Shure, K., "Fission Product Decay Energy" in Bettis Technical Review, WAPD-BT-24, p. 1-17, December 1961.

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14. Deleted.

15. Burnett, T. W. T., et al., "LOFTRAN Code Description," WCAP-7907-P-A (Proprietary), WCAP-7907-A (Non-Proprietary) April 1984.

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18. Risher, D. H., Jr. and Barry, R. F., "TWINKLE - A Multi-Dimensional Neutron Kinetics Computer Code," WCAP-7979-P-A (Proprietary) and WCAP-8028-A (Non-Proprietary), January 1975.

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20. Deleted by Amendment 80.

21. ~~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.~~ Deleted

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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 Section 4.4.3.4 and Reference 13.

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b. 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.

Results

a. One or More Dropped RCCAs

Replace with INSERT A

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

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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 limiting value.~~

INSERT B (new paragraph)

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b. 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 is in a timeframe in excess of ten minutes following the incident.~~

Replace with INSERT C

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INSERT A

Single or multiple dropped RCCAs within the same group result in a negative reactivity insertion. Power may be reestablished either by reactivity feedback or control bank withdrawal. Manual rod control (or with control rod stops) cases are bounded by automatic control because the reactivity insertions can only result from reactivity feedback and no power overshoot caused by control bank withdrawal can occur.

INSERT B

For evaluation of the dropped rod event, transient system conditions at the limiting point in the transient (i.e., statepoints) are calculated. No credit for any direct trip due to the dropped rod(s) is taken in the analysis (Reference 13). The analysis also assumes no automatic power reduction features are actuated by the dropped rod(s). The statepoints are provided for conditions which cover the range of reactivity parameters expected to occur during core life. The minimum calculated pre-rod drop hot channel factor is verified to be greater than the design value for each core cycle, demonstrating that in all cases, the minimum DNBR remains above the limiting value.

INSERT C

A dropped RCCA bank typically results in a reactivity insertion greater than 500 pcm. The transient will proceed as described in part "a" above. The statepoint hot channel factor is used along with the transient statepoints and the dropped rod limit lines to confirm that the DNB design basis is met following a dropped rod event with no direct trip due to the dropped rods and no automatic power reduction features.

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c. 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 limiting value. This case is analyzed assuming the initial reactor power, pressure, and RCS temperatures are at their nominal values including uncertainties 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 limiting value. This case is analyzed assuming the initial reactor power, pressure, and RCS temperatures are at their nominal values, including uncertainties 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.

15.2.3.3 Conclusions

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, 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 limiti~~ng~~ value; therefore, the DNB design basis is met.

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