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

January 11, 1979

Docket No. 50-409

Mr. Frank Linder
General Manager
Dairyland Power Cooperative
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Dear Mr. Linder:

Enclosed is a copy of our redraft evaluation of Systematic Evaluation Program topic IV-1A (Operation with less than all loops in service). You are requested to examine the facts upon which the staff has based its evaluation and respond either by confirming that the facts are correct, or by identifying any error. If in error, please supply corrected information for the docket. We encourage you to supply for the docket any other material related to this topic that might affect the staff's evaluation.

Please note that this evaluation supersedes the evaluation issued by our letter dated August 17, 1978.

It would be most helpful if your comments were received within 30 days of the date you receive this letter.

Sincerely,

Dennis L. Ziemann

Dennis L. Ziemann, Chief
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Enclosures:
Topics IV-1A

cc w/enclosures:
See next page

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SYSTEMATIC EVALUATION PROGRAM

Topic IV-I-A: Operation with less than all loops in service.

PLANT: LaCrosse Boiling Water Reactor (LACBWR)

Discussion

The majority of the presently operating BWR's and PWR's are designed to permit operation with less than full reactor coolant flow. If a PWR reactor coolant pump or a BWR recirculation pump becomes inoperative, the flow provided by the remaining loop or loops is sufficient for steady state operation at some definable power level, usually less than full power.

Plants authorized for long term operation with one reactor coolant pump or recirculation pump out of service have submitted, and the staff has approved, the necessary ECCS, steady state, and transient analyses. The remaining PWR and BWR licensees have Technical Specifications which require reactor shutdown within 24 hours if one of the operating loops becomes inoperable and cannot be returned to operation within the time period. LACBWR has no restriction on operating in the (n-1) loop mode and our review indicated that analyses to justify operation in this mode had not been submitted.

Evaluation

Several factors have to be considered when evaluating (n-1) loop operation; (1) the impact on normal operation (i.e. are there adequate thermal margins when one considers the effect of anticipated transients), (2) the potential for a new accident (in this case a coldwater accident caused by the startup of the inactive pump), and (3) the potential effect on accidents which are analyzed (principally the LOCA and locked rotor accident).

One factor that can affect all three of these considerations is the effect of one loop operation on reactor coolant flow distribution. LACBWR is a two loop BWR with a thermal rating of 165 megawatts. The forced-circulation system cools the reactor by circulating as much as 30,000 gpm of water. The primary water flows upward through the core and then downward through the steam separators to the recirculating water outlet plenum. The water then flows to the 16 inch forced-circulation pump suction manifold through four 16 inch nozzles and is mixed with reactor feedwater that enters the manifold from four 4 inch connections. From the manifold, the water flows through 20 inch suction lines to the two 15,000 gpm variable speed forced-circulation pumps. Hydraulically-operated rotoport valves are at the suction and discharge of each pump. The 20 inch pump discharge line returns the water to the 16 inch forced circulation pump discharge manifold. From the manifold, the water flows back to the core through four equally spaced 16 inch nozzles in the bottom of the reactor vessel.

The physical arrangement of the forced circulation system as described above (i.e. common discharge header and common suction header) intuitively indicates that flow perturbations will not be introduced to the system, that is, at a specified flow it is expected that the reactor will not discern the difference between two pumps or one pump operating. In addition, a flow stability analysis, performed by Allis-Chalmers, (reference 2), simulating one pump and two pump flow situations at LACBWR shows that no flow oscillations are expected to occur during one pump operation. The staff concludes that due to the system configuration and the Allis-Chalmers analysis uneven or asymetric flow conditions will be neglible.

With regard to normal operation (with one loop), since we have concluded that there are minimal effects on flow distribution, the thermal margin protection specified in the Technical Specification for reduced flow are adequate.

With regard to the potential for a new accident, the staff considered the potential for a cold water injection accident caused by the startup of the inactive loop.

The LACBWR forced-circulation system 20 inch discharge valve is electrically interlocked to close whenever its associated pump is tripped or at zero speed and the pump in the other loop is at greater than zero speed. A second interlock controls the position of a 2 inch bypass valve around the discharge valve for the purpose of maintaining a thermal equilibrium between the two loops. An interlock causes the discharge valve to remain in the closed position anytime the temperature differential between the loops is greater than 10°F. The bypass valve opens anytime the discharge valve is out of the fully open position. During single loop operation the suction valve is locked in the fully open position. This configuration provides for a backflow through the loop which maintains the temperature differential at a minimum. We conclude, that since the idle loop is maintained in tehrmal equilibrium by interlock with the operating loop, no significant cold water injection can occur and therefore additional restrictions are not required on reinstating the idle loop to operation.

With regard to the potential effect on postulated accidents, the staff considers the LOCA and locked rotor to be the most bounding in terms of the effects of single loop operation. For the LOCA the primary areas of concern are (1) the effect of difference in water inventory (in the vessel and operating loops), (2) energy removal from the core during blowdown due to path of primary water to the break, and (3) the effect of reduced power level and stored energy in the fuel.

Regarding the water inventory, the reactor water level control system at LACBWR is one of essentially constant mass, that is, water level is increased or decreased to account for the steam voids present during variations in power level. Although the indicated water level at LACBWR is a measure of the actual inventory in the reactor vessel, since the lower nozzle for water level measurement is below the regions in the core that contain significant voids, the level program is based on steam voids present during full power and full flow. Since this mode of operation yields essentially the same void fraction at 100 percent flow and 50 percent flow, the inventory of water in the vessel does not change. The staff, therefore concludes, that it is reasonable to assume that there are no significant inventory differences between single and dual loop operation. Further assurance of maintaining constant mass is provided by a Technical Specification (4.2.2.9) limiting operation to 50 percent of rated reactor power during single loop operation. This bounds LACBWR so that control rods cannot be varried to increase reactor power while at maximum flow on one pump thereby producing a higher reactor power resulting in a greater void fraction and potential for decreasing the mass inventory. Additionally, since the bypass line is open in the idle loop (discussed above), the inventory of water is essentially the same as that used in the LOCA analysis. The staff therefore concludes, based on the above, that the inventory available during single loop operation would not be appreciable changed from that assumed available during dual loop operation at full power and full flow.

Regarding the effect on energy removal due to blowdown flow distribution, the location of the limiting LOCA is such that blowdown effluent would be preferentialy routed through the core for that portion of the transient before the 2" bypass line is closed and the 20" recirc line opened. The change in blowdown flow will be slight but in a direction to enhance heat removal from the core.

The stored energy and decay heat strongly affect peak clad temperatures. If the power level is effectively halved, the stored energy of the fuel is proportionally reduced resulting in peak clad temperatures significantly below those calculated. Fuel burnup and the clad gap effect the relationship between power level and stored energy in the fuel but are secondary effects so that reducing power level by a factor of 2 reduces the stored energy by approximately 2 with a corresponding decrease in peak clad temperature during the LOCA.

The accident most affected by the single loop operating mode is the locked pump rotor. A seizure of the rotor in the operating loop pump causes a complete loss of pumping flow without benefit of pump coast-down. In the event of disrupted flow at LACBWR, reactor water level would decrease to the reactor scram setpoint and initiate the high pressure emergency core spray. This same signal would cause the reactor building steam isolation valve to close. Closure of the steam isolation valve initiates shutdown condenser operation. The forced circulation system discharge and suction valves are interlocked with the shutdown condenser is in service providing a flow path for natural circulation. Shutdown cooling by natural circulation through the shutdown condenser would proceed in a normal manner except that flow resistance would be greater in one loop. We estimate that flow resistance (K) to be about 4 times higher with a locked rotor than a free wheeling pump based on LOFT predictions. Paragraph 14.3.9 of LCBWR Safeguards report states that natural circulation flow (estimated to be 4000 gpm) can remove up to 30 percent of full power heat generation at 1285 psig without violating thermal-hydraulic design criteria or approaching burnout heat flux. LCBWR is restricted to 50% power by tech spec when in on n-1 operating mode. When reactor scram occurs, the power generation will immediately decrease to about 7% of initial power or 3.5% of full power. Heat generation would then decay, following the ANS curve.

Table 14-3A of the Safeguards report indicates that 2700 gpm natural circulation will remove 6% power. Our conclusion is that even with the flow resistance increase in one recirculation loop, decay heat could be removed by natural circulation alone. Additional assurance is derived by actuation of the high pressure core spray and operation of the shutdown condenser following a locked rotor accident.

Based on our review of the above we conclude that operation with less than all loops in service at LACBWR is acceptable and no facility or Technical Specification changes are required.

References

1. LACBWR Technical Specifications 4.2.2.9
2. ACNP 65511 Dynamic Analysis, two loop operation, February 1965 sec.5,3.5,3.5.1
3. Power test program results, ACNP 70501, sec.3.1.8
4. LACBWR Hazards Summary Report, sec.14.3.9 Loss of forced circulation flow
5. LACBWR Hazards Summary Report, forced circulation system description