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Docket Nos: 50-331

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MEMORANDUM FOR: Thomas M. Novak, Assistant Director for Operating Reactors
Division of Licensing

FROM: Themis P. Speis, Assistant Director for Reactor Safety
Division of Systems Integration

SUBJECT: SAFETY EVALUATION OF DUANE ARNOLD SINGLE LOOP OPERATION

Plant Name:	Duane Arnold
Docket No:	50-331
NSSS Supplier:	General Electric
Responsible Branch:	ORB-2
Project Manager:	K. T. Eccleston
Review Status:	Complete

Enclosed is the Safety Evaluation Report to permit Duane Arnold Energy Center to operate on a single loop with power limited to 50%. This completes one action under multiplant item E-04.(TAC #43126).

Themis P. Speis, Assistant Director
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Enclosure:
As stated

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ENCLOSURE
SAFETY EVALUATION REPORT N-1 LOOP OPERATION
DUANE ARNOLD ENERGY CENTER

1.0 INTRODUCTION

The current DAEC Technical Specifications do not allow plant operation beyond 24 hours if an idle recirculation loop cannot be returned to service. The ability to operate at reduced power with a single loop is highly desirable from availability/outage planning standpoint in the event that maintenance or component unavailability renders one loop inoperable. Such events have occurred several times and caused the licensee to apply for temporary amendment, some times on an emergency basis.

By letter dated October 17, 1980, Iowa Electric Light and Power Company (the licensee) requested changes to the Technical Specification for The Duane Arnold Energy Center (DAEC). The requested changes would permit DAEC to operate at up to 82% of rated power with one recirculation loop out of service for unlimited time. While analyses indicate that it may be safe to operate BWRs on a single loop in the range of 82% of rated power, the experience (reference letter from L. M. Mills, TVA dated March 17, 1980 to H. Denton, NRC) at Browns Ferry Unit 1 has caused concern about flow and power oscillations. Because single loop operation at 50% rated power at several plants, including Browns Ferry, has shown to result in acceptable flow and power characteristics, we will permit the DAEC to operate at power levels up to 50% of rated with one loop out of service for an unlimited time period.

If requested, we will reconsider operation up to 82% of rated power for DAEC with one recirculation loop out of service after staff concerns stemming from Browns Ferry - Unit 1 single loop operation are satisfied.

2 EVALUATION

2.1 Accidents (Other than Loss of Coolant Accident (LOCA) and Transients Affected by One Recirculation Loop Out of Service

2.1.1 One Pump Seizure Accident

The licensee states that the one-pump seizure accident is a relatively mild event during two recirculation pump operation. Similar analyses were performed to determine the impact this accident would have on one recirculation pump operation. These analyses were performed using NRC approved models for a large core BWR/4 plant. The analyses were conducted from steady-state operation at the following initial conditions, with the added condition of one inactive recirculation loop. Two sets of initial conditions were assumed:

a. Thermal Power = 75% and core flow = 58% of rated

b. Thermal Power = 82% and core flow = 56% of rated

These conditions were chosen because they represent reasonable upper limits of single-loop operation within existing Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) and Minimum Critical Power Ratio (MCPR) limits at the same maximum pump speed. Pump seizure was simulated by setting the single operating pump speed to zero instantaneously.

The anticipated sequence of events following a recirculation pump seizure which occurs during plant operation with the alternate recirculation loop out of service is as follows:

a. The recirculation loop flow in the loop in which the pump seizure occurs drops instantaneously to zero.

b. Core voids increase which result in a negative reactivity insertion and a sharp decrease in neutron flux.

c. Heat flux drops more slowly because of the fuel time constant.

d. Neutron flux, heat flux, reactor water level, steam flow, and feedwater flow all exhibit transient behaviors. However, it is not anticipated that the increase in water level will cause a turbine trip and result in scram.

It is expected that the transient will terminate at a condition of natural circulation and reactor operation will continue. There will also be a small decrease in system pressure.

The licensee concludes that the MCPR for the pump seizure accident for the large core BWR/4 plant was determined to be greater than the fuel cladding integrity safety limit; therefore, no fuel failures were postulated to occur as a result of this analyzed event. These results are also applicable to DAEC.

2.1.2 Abnormal Transients

2.1.2.1 a. Idle Loop Startup

The idle loop startup transient was analyzed, in the DAEC FSAR, with an initial power of 55%. The licensee is to operate at no greater than 50% power with one loop out of service. Additionally, the Technical Specifications are being modified to require that, during single loop operation, the suction valve in the idle loop be shut and electrically disconnected. These measures are being taken to preclude startup of an idle loop.

b. Flow Increase

For single-loop operation, the rated condition steady-state MCPR limit is increased by 0.01 to account for increased uncertainties in the core total flow and Traversing In-core Probe (TIP) readings. The MCPR will vary depending on flow conditions. This leads to the possibility of a large inadvertent flow increase which could cause the MCPR to decrease below the Safety Limit for a low initial MCPR at reduced flow conditions. Therefore, the required MCPR must be increased at reduced core flow by a flow factor, K_f. The K_f factors are derived assuming both recirculation loops increase speed to the maximum permitted by the scoop tube position set screws. This condition maximizes the power increase and hence the ΔMCPR for transients initiated from less than rated conditions. When operating on one loop the flow and power increase will be less than associated with two pumps increasing speed, therefore, the K_f factors derived from the two-pump assumption

are conservative for single-loop operation.

c. Rod Withdrawal Error

The rod withdrawal error at rated power is given in the FSAR for the initial core and in cycle dependent reload supplemental submittals. These analyses are performed to demonstrate that, even if the operator ignores all instrument indications and the alarm which could occur during the course of the transients, the rod block system will stop rod withdrawal at a minimum critical power ratio which is higher than the fuel cladding integrity safety limit. Correction of the rod block equation and lower initial power for single-loop operation assures that the MCPR safety limit is not violated.

One-pump operation results in backflow through 8 of the 16 jet pumps while flow is being supplied to the lower plenum from the active jet pumps. Because of this backflow through the inactive jet pumps the present rod-block equation and APRM settings must be modified. The licensee has modified the two-pump rod block equation and APRM settings that exist in the Technical Specification for one-pump operation and the staff has found them acceptable.

The staff finds that one loop transients and accidents other than LOCA, which is discussed below, are bounded by the two loop operation analysis and are therefore acceptable.

2.2 Loss of Coolant Accident (LOCA)

The licensee has contracted General Electric Co. (GE) to perform single loop operation analysis for DAEC LOCA. The licensee states that evaluation of these calculations (that are performed according to the procedure outlined in NEDO-20566-2, Rev. 1) indicates that a multiplier of 0.86 (7x7 fuel), 0.87 (8x8 fuel), 0.87 (8x8R fuel) (Ref: - NEDE 24272 July 1980) should be applied to the MAPLHGR limits for single loop operation of the DAEC.

We find the use of these MAPLHGR multipliers to be acceptable.

3. Thermal Hydraulics

The licensee has confirmed that analysis uncertainties are independent of whether flow is provided by two loops or single loop. The only exceptions to this are core total flow and TIP reading. The effect of these uncertainties is an increase in the MCPR by .01, which is more than offset by the K_f factor required at low flows. The steady state operating MCPR with single-loop operation will be conservatively established by multiplying the K_f factor to the rated flow MCPR limit.

4. Stability Analysis

As indicated in the applicant's submittal NEDO-24272, operation along the minimum forced recirculation line with one pump running at minimum speed is more stable than operation with natural circulation flow only, but is less stable than operating with both pumps operating at minimum speed.

The licensee will be required to operate in master manual to reduce the effects of instabilities due to controller feedback. The staff has accepted previous stability analyses results as evidence that the core can be operated safely while our generic evaluation of BWR stability characteristics and analysis methods continues. The previous stability analysis results include natural circulation conditions and thus bound the single loop operation. We conclude that with appropriate limitations to recognize and avoid operating instabilities, that the reactor can be operated safely in the single loop mode. Our evaluation of the flow/power oscillations evidenced in Browns Ferry will continue and any conclusions resulting from this study will be applied to DAEC.

5. SUMMARY ON SINGLE LOOP OPERATION

1. Steady State thermal power level will not exceed 50%

Operating at 50% power with appropriate T-S changes was approved on a temporary basis for the Duane Arnold Plant and Peach Bottom Units 2 and 3 (Safety Evaluation Reports (SER) dated May 6, 1980, July 17, 1980, July 31, 1980 and May 15, 1981 respectively). Authorization for single loop operation for extended periods was given to Dresden Units 2 and 3 and Quad Cities Units 1 and 2 (SER July 9, 1981). It was concluded that for operation at 50%, power transient and accident bounds would not be exceeded for these plants.

2. Minimum Critical Power Ratio (MCPR) Safety Limit will be increased by 0.01 to 1.08

The MCPR Safety LImit will be increased by 0.01 to account for increased uncertainties in core flow and Traversing Incore Probe (TIP) readings. The licensee has reported that this increase in the MCPR Safety Limit was addressed in GE reports specifically for DAEC for one loop operation. On the basis of previous staff reviews for Duane

Arnold and Peach Bottom and on our review of plant comparisons we find this analysis acceptable for DAEC.

3. Minimum Critical Power Ratio (MCPR) limiting condition for operation (LCO) will be increased by 0.01 to 1.26, 1.25, and 1.27 for 7x7, 8x8m 8x8R fuel respectively

The staff require that the operating limit MCPR be increased by 0.01 and multiplied by the appropriate two loop K_f factors that are in the DAEC T-S. This will preclude an inadvertant flow increase from causing the MCPR todrop below the safety limit . MCPR. This was also approved by the staff for Peach Bottom 2 and 3.

4. The Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) limits will be reduced by appropriate multipliers.

The licensee proposed reducing the T-S MAPLHGR by 0.86 (7x7 fuel); 0.87 (8x8 fuel); and 0.87 (8x8R) for single loop operation. These reductions were based on analyses by General Electric (GE) in reports NEDE 24011-P-A-1 and NEDO 24272. The Peach Bottom units were allowed to operate with their MAPLHGR values reduced by factors of 0.71, 0.83, and 0.81 for an unlimited period of time for the three types of fuel.

5. The APRM Scram and Rod Block Setpoints and RBM Setpoints will be reduced

The licensee proposed to modify the two loop APRM Scram, Rod Block and Rod Block Monitor (RBM) setpoints to account for back flow through half the jet pumps. The changes were based on plant specific analyses by GE. These setpoint equations will be changed in the DAEC T-S. The above changes are similar to the Peach Bottom T-S changes and are acceptable to the staff.

6. The Suction valve in the idle loop is closed and electrically isolated

The licensee will close the recirculation pump suction valve and remove power from the valve. In the event of a loss of coolant accident this would preclude partial loss of LPCI flow through the recirculation loop degrading the intended LPCI performance. The removal of power also helps to preclude a start up of an idle loop transient.

7. The Equalizer line between the loops will be isolated.

The licensee will close appropriate valves in the cross-tie (equalizer) line between the loops. The previously discussed analysis assumed the two loops were isolated. Therefore, it is required that the cross-tie valve be closed.

8. The recirculation control will be in manual control.

The staff requires that the licensee operate the recirculation system in the manual mode to eliminate the need for control system analyses and to reduce the effects of potential flow instabilities. This was also required of Peach Bottom.

9. Surveillance Requirements

The staff requires that the licensee perform daily surveillance on the jet pumps to ensure that the pressure drop for one jet pump in a loop does not vary from the mean of all jet pumps in that loop by more than 5%. to 10 %

10. Provisions to allow operation with one recirculation loop out of service.

1. The steady-state thermal power level will not exceed 50% of rated
2. The Minimum Critial Power Ratio (MCPR) Safety Limit will be increased by .01 to 1.08 (T.S. 1.1A)
3. The MCPR Limiting Condition for Operation (LCO) will be increased by 0.01 to 1.26, 1.25 and 1.27 for 7x7 and 8x8, 8x8R fuel respectively (T.S.)
4. The Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) limits will be reduced by multiplying 0.86, 0.87, and 0.87 for 7x7, 8x8 and 8x8R fuel respectively (T.S. reference 3-12-1)
5. The APRM Scram and Rod Block Setpoints and the RBM Setpoints, shall be reduced to read as follows:

T.S. 2.1.A.1	S $\leq$ .66W + 54	
T.S. 2.1.A.1*	S $\leq$ (.66W + 50.7)	FRP/MFLPD
T.S. 2.1.A.3	S $\leq$ .66W + 42	
T.S. 2.1.A.3*	S $\leq$ (.66W + 38.7)	FRP/MFLPD
T.S. 3.2.C.		
APRM Upscale	$\leq$ (.66W + 38.7)	FRP/MFLPD
RBM Upscale	$\leq$ .66W + 39	

6. The suction valve in the idle loop is closed and electrically isolated until the idle loop is being prepared for return to service.

* In the event that MFLPD exceeds FRP.

normally 50% - 8100-1C

7. APRM flux noise will be measured once per shift and the recirculation pump speed will be reduced if the flux noise exceeds 5-percent peak to peak.

8. The core plate delta p noise be measured once per shift and the recirculation pump speed will be reduced if the noise exceeds 1 psi peak to peak.

DAEC has been operated with one loop on several occasions. During the periods of single loop operation, no anomalous behavior was observed. Therefore, based upon the above evaluation and a history of successful operation we conclude that single-loop operation of DAEC, up to a power level of 50% and in accordance with the proposed TSs, will not exceed the accident and transient bounds previously found acceptable by the NRC staff and is therefore acceptable.