ENCLOSURE

SAFETY EVALUATION REPORT N-1 LOOP OPERATION

BROWNS FERRY NUCLEAR PLANT UNITS 1, 2, AND 3 (BFNP-1, 2, 3)

1.0 INTRODUCTION

The current BFNP-1, 2, and 3 Technical Specification 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 rendered one loop inoperable.

By letter dated March 4, 1982, Tennessee Valley Authority (the licensee) requested changes to the Technical Specification for Single Loop Operation of BFNP-1, 2, and 3. The requested changes would permit BFNP-1, 2 and 3 to operate at up to 50% 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 higher than 50% 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. However, because single loop operation at 50% rated power at several plants, including Browns Ferry Plant Unit-1, has shown to result in acceptable flow and power characteristics, we will permit TVA to operate at power levels up to 50% of rated with one loop out of service during Cycle 5.

If requested, we will reconsider operation at a higher power level for BFNP-1, 2 & 3 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 BFNP-1. 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 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 results in a negative reactivity insertion and 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 BFNP-1 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 applicable to Browns Ferry Nuclear Plant Units 2 and 3.

2.1.2 Abnormal Transients

2.1.2.1 a. Idle Loop Startup

The idle loop startup transient was anlayzed, in the BFNP-1, 2 & 3 FSAR, with an initial power of 68%. 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 loop pumps increase speed to the maximum permitted by the scoop tube position set screws. These conditions maximize the power increase and hence maximum MCPR 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 inital 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 10 of the 20 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 BFNP-1, 2 & 3 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 0.70 (7x7 fuel), 0.83 (8x8 fuel), 0.82 (8x8R Fuel) 0.82 (P8x8R fuel) (Ref: - NEDE 24236 May 1981) should be applied to the MAPLHGR limits for single loop operation of BFNP 1, 2 & 3.

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

3. SUMMARY ON SINGLE LOOP OPERATION

1. Steady State Thermal Power Level will not exceed 50%

Several BWRs have previously been authorized to operate for a short period of time with one recirculation loop. In all but one case, power level has been limited to 50 percent; the one exception was Browns Ferry Unit No. 1. On September 29, 1978, based on analyses performed for TVA by the General Electric Company (GE), we authorized TVA to operate Browns Ferry 1 for about two months at power levels up to 82 percent of full rated power. During power ascension with Browns Ferry 1 in single loop operation, jet pump flow variations were noted in the active loop above a pump speed of 65 percent of rated flow (about 59 percent of rated power). Whenever TVA tried to increase the power level above this point, they noted variations in jet pump flow, neutron flux, and related parameters. Accordingly, TVA administratively limited Browns Ferry Unit 1 operation to less than 60 percent for the approximately two months the unit operated on a single loop.

While analyses indicate that it should be safe to operate BWRs on a single loop in the range of 85 percent of rated power, the experience at Browns Ferry Unit 1 has raised concerns about authorizing single loop operation for BWRs above 50 percent rated power until there is a better understanding of what may have caused the variations in this facility.

Operating at 50% power with appropriate T-S changes was approved on a long term basis for the Cooper Nuclear Station, Duane Arnold Plant and Peach Bottom Units 2 and 3 (Safety Evaluation Reports (SER) dated December 10, 1981, November 19, 1981 and May 15, 1981 respectively). Authorization of single loop operation for extended periods was also given to Dresden Unit 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 BFNP-1, 2 & 3 for one loop operation. On the basis of previous staff reviews for Cooper, Duane Arnold and Peach Bottom and our review of plant comparisons we find this analysis acceptable for BFNP-1, 2 & 3.

3. Minimum Critical Power Ratio (MCPR) Limiting Condition for Operation (LCO) will be Increased by 0.01.

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 BFNP-1, 2 & 3 T-S. This will preclude an inadvertent flow

increase from causing the MCPR to drop 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 0.70 (7x7 fuel); 0.83 (8x8 fuel); 0.82 (8x8R) and 0.82 (P8x8R) for single loop operation. These reductions were based on analyses by General Electric (GE) in reports NEDE 24011-P-A-1 and NEDO 24236. 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 first three types of fuel listed above.

5. The APRM Scram and Rod Block 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 anlayses by GE. These setpoints equations will be changed in the BFNP-01, 2 & 3 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%.

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 Critical 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

4. The Maximum Average Planar Linear Heat Generation Rate (MAPLHGR) limits will be reduced by multiplying 0.70, 0.83, 0.82, and 0.82 for 7x7, 8x8, 8x8R, P8x8R fuel respectively (T.S. reference Table 3.5I)

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 _ (.66W + 54% -0.66 Δ W)

T.S. 2.1.A.1* S _ (.66W + 54% -0.66 Δ W) FRP/MFLPD

T.S. 2.1.A.3 S _ (.66W + 42% -.66 Δ W)

T.S. 2.1.A.3* S _ (.66W + 42% -0.66 Δ W)

APRM UPscale _(.66 + 42% -0.66 Δ W)

RBM Upscale _(.66W +40%)

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

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.

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*In the event that MFLPD exceeds FRP.

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

Therefore, based upon the above evaluation and a history of successful operation of other BWRs of the same type as BFNP-1, 2 & 3 we conclude that single-loop operation of BFNP-1,2,& 3 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.

The approval for single loop operation up to a power level of 50% is authorized during cycle 5 only.