UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 16, 2009

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT NO. 2 - ISSUANCE OF AMENDMENT RE: TECHNICAL SPECIFICATION CHANGE TO MODIFY REACTOR COOLANT SYSTEM FLOW VERIFICATION (TAC NO. ME0125)

Dear Sir or Madam:

The Commission has issued the enclosed Amendment No. 286 to Renewed Facility Operating License No. NPF-6 for Arkansas Nuclear One, Unit No. 2 (ANO-2). The amendment consists of changes to the Technical Specifications (TSs) in response to your application dated November 13, 2008, as supplemented by letters dated June 1, July 14, and August 17, 2009.

The amendment modifies TS 3.3.1.1, Reactor Protective Instrumentation, specifically Table 4.3-1 and associated Notes 7 and 8, to clarify and streamline Reactor Coolant System flow verification requirements associated with the Departure from Nucleate Boiling Ratio reactor trip signal.

A copy of our related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

N. Kaly Kalyanam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-368

Enclosures:
1. Amendment No. 286 to NPF-6
2. Safety Evaluation

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

ENTERGY OPERATIONS, INC.

DOCKET NO. 50-368

ARKANSAS NUCLEAR ONE, UNIT NO. 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 286
Renewed License No. NPF-6

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Entergy Operations, Inc. (the licensee), dated November 13, 2008, as supplemented by letters dated June 1, July 14, and August 17, 2009, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this license amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and Paragraph 2.C.(2) of Renewed Facility Operating License No. NPF-6 is hereby amended to read as follows:

    (2) Technical Specifications

    The Technical Specifications contained in Appendix A, as revised through Amendment No. 286, are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications

3. The license amendment is effective as of its date of issuance and shall be implemented within 90 days from the date of issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Michael T. Markley, Chief
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Attachment:
Changes to the Renewed Facility
Operating License No. NPF-6
Technical Specifications

Date of Issuance: September 16, 2009

ATTACHMENT TO LICENSE AMENDMENT NO. 286

RENEWED FACILITY OPERATING LICENSE NO. NPF-6

DOCKET NO. 50-368

Replace the following pages of the Renewed Facility Operating License No. NPF-6 and Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

Operating License

REMOVE	INSERT
-3-	-3-

Technical Specifications

REMOVE	INSERT
3/4 3-7	3/4 3-7
3/4 3-9	3/4 3-9

(4) EOI, pursuant to the Act and 10 CFR Parts 30, 40 and 70 to receive, possess and use at any time any byproduct, source and special nuclear material as sealed neutron sources for reactor startup, sealed sources for reactor instrumentation and radiation monitoring equipment calibration, and as fission detectors in amounts as required;

(5) EOI, pursuant to the Act and 10 CFR Parts 30, 40 and 70, to receive, possess, and use in amounts as required any byproduct, source or special nuclear material without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactive apparatus or components; and

(6) EOI, pursuant to the Act and 10 CFR Parts 30 and 70, to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This renewed license shall be deemed to contain and is subject to conditions specified in the following Commission regulations in 10 CFR Chapter 1; Part 20, Section 30.34 of Part 30, Section 40.41 of Part 40, Sections 50.54 and 50.59 of Part 50, and Section 70.32 of Part 70; and is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect; and is subject to the additional conditions specified or incorporated below:

(1) Maximum Power Level

EOI is authorized to operate the facility at steady state reactor core power levels not in excess of 3026 megawatts thermal. Prior to attaining this power level EOI shall comply with the conditions in Paragraph 2.C.(3).

(2) Technical Specifications

The Technical Specifications contained in Appendix A, as revised through Amendment No. 286 are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications.

Exemptive 2nd paragraph of 2.C.2 deleted per Amendment 20, 3/3/81.

(3) Additional Conditions

The matters specified in the following conditions shall be completed to the satisfaction of the Commission within the stated time periods following issuance of the renewed license or within the operational restrictions indicated. The removal of these conditions shall be made by an amendment to the renewed license supported by a favorable evaluation by the Commission.

2.C.(3)(a) Deleted per Amendment 24, 6/19/81.

TABLE 4.3-1

REACTOR PROTECTION INSTRUMENTATION SURVEILLANCE REQUIREMENTS

FUNCTIONAL UNIT	CHANNEL CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST	MODES IN WHICH SURVEILLANCE REQUIRED
1. Manual Reactor Trip	N.A.	N.A.	S/U (1)	N.A.
2. Linear Power Level – High	S	D (2,4) M (3,4) Q (4)	TA (10)	1,2
3. Logarithmic Power Level – High	S	R (4)	TA (10) S/U (1)	1,2,3,4,5 and *
4. Pressurizer Pressure – High	S	R	TA (10)	1,2
5. Pressurizer Pressure – Low	S	R	TA (10)	1,2,3*,4*,5*
6. Containment Pressure – High	S	R	TA (10)	1,2
7. Steam Generator Pressure – Low	S	R	TA (10)	1,2,3*,4*,5*
8. Steam Generator Level – Low	S	R	TA (10)	1,2
9. Local Power Density – High	S	D (2,4) R (4,5)	TA (10) R (6)	1,2
10. DNBR – Low	S	S (7), D (2,4), R (4,5)	TA (10) R (6)	1,2
11. Reactor Protection System Logic	N.A.	N.A.	TA (10)	1,2,3*,4*,5*
12. Reactor Trip Breakers	N.A.	N.A.	M	1,2,3*,4*,5*
13. Core Protection Calculators	S	D (2,4) R (4,5)	TA (9,10) R (6)	1,2
14. CEA Calculators	S	R	TA (10) R (6)	1,2

(7) - Above 70% of RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the RCS total flow rate determined by either using the reactor coolant pump differential pressure instrumentation or by calorimetric calculations and, if necessary, adjust the CPC flow calibration addressable constant FC1 such that each CPC indicated flow is less than or equal to the measured flow rate.

(8) - Deleted

(9) - The CPC CHANNEL FUNCTIONAL TEST shall include the verification that the correct values of addressable constants are installed in each OPERABLE CPC.

(10) - On a STAGGERED TEST BASIS.

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO TECHNICAL SPECIFICATION CHANGES TO MODIFY REACTOR COOLANT SYSTEM FLOW VERIFICATION FOR CORE PROTECTION CALCULATORS (CPC) DEPARTURE FROM NUCLEATE BOILING RATIO (DNBR) CALCULATIONS

AMENDMENT NO. 286 TO

RENEWED FACILITY OPERATING LICENSE NO. NPF-6

ENTERGY OPERATIONS, INC.

ARKANSAS NUCLEAR ONE, UNIT NO. 2

DOCKET NO. 50-368

1.0 INTRODUCTION

By application dated November 13, 2008 (Reference 1), as supplemented by letters dated June 1 (Reference 2), July 14 (Reference 3), and August 17 (Reference 4), 2009, Entergy Operations, Inc. (the licensee), requested changes to the Technical Specifications (TSs) for Arkansas Nuclear One, Unit No. 2 (ANO-2). The supplemental letters dated June 1, July 14, and August 17, 2009, provided additional information that clarified the application, did not expand the scope of the application as originally noticed, and did not change the Nuclear Regulatory Commission (NRC) staff's original proposed no significant hazards consideration determination as published in the *Federal Register* on January 27, 2009 (74 FR 4769).

The proposed changes to TS Table 4.3-1, Reactor Protection Instrumentation Surveillance Requirements, and associated Notes (7) and (8) for ANO-2 would allow a more accurate reactor coolant pump (RCP) differential pressure based flow indication, as calculated by the Core Operating Limits Supervisory System (COLSS), to be used as the calibration standard at all surveillance intervals.

ANO-2, a plant with core protection calculators (CPCs) and COLSS, uses a combination of the reactor protection system (RPS) that includes the CPCs, and the limiting conditions for operation (LCOs) maintained by the operator using the COLSS to avoid violation of the safety limit of the departure from nucleate boiling ratio (DNBR) during normal operation and anticipated operational occurrences (AOOs). The COLSS provides the operator with information for monitoring the LCO based on the DNBR margin, linear heat margin, axial shape index, azimuthal tilt and core power. The CPC with the RPS initiates reactor trips based on low DNBR and high local power density. Both CPCs and COLSS use measured reactor coolant system (RCS) flow rates to calculate the DNBR for the CPCs to provide reactor trips and for the COLSS to provide alarms. The RCS flow rates are currently measured by the CPCs using speed sensors and by the COLSS using the RCP head curve and differential pressure (ΔP), and are periodically calibrated to a reference RCS flow rate, which is measured by a calorimetric method from RCS cold-leg and hot-leg temperature sensors and secondary calorimetric power. CPC measures the RCS flow based on RCP speed with calibration to the COLSS measured flow every shift.

The licensee indicated that the calorimetric method would result in overly conservative RCS flow rates because of the effects of flow stratification on the RCS hot-leg temperature (Reference 1). The conservative (low) flow rates result in a smaller margin to the safety limit for DNBR calculations in the CPCs and COLSS.

The licensee proposed TS changes to allow RCP ΔP-based flow rates (the RCP ΔP method), as calculated by the COLSS, to be used as the calibration standard at all surveillance intervals for RCS flow rates used in CPCs and COLSS. The proposed changes would improve plant operating performance and flexibility, and reduce the probability of unnecessary reactor trip by avoiding the excess conservatism in RCS flow measurements introduced by using the calorimetric method as currently applied to RCS flow calibration for the COLSS and CPC.

2.0 REGULATORY EVALUATION

General Design Criterion (GDC) 10, "Reactor Design," of Appendix A to Title 10 of the *Code of Federal Regulations*, Part 50 (10 CFR Part 50) requires that "[T]he reactor core and associated coolant, control, and protection systems be designed with appropriate margin to assure that specified acceptable fuel design limits [SAFDLs] are not exceeded during any conditions of normal operation, including the effects of anticipated operational occurrences." In the application of pressurized-water reactors (PWRs), the safety limit of departure from nucleate boiling ratio (SLDNBR) is established to assure compliance with SAFDLs. The SLDNBR is the DNBR limit, which corresponds to a 95 percent probability at a 95 percent confidence level that departure from nucleate boiling (DNB) will not occur. The CPC-initiated reactor trip on a low DNBR signal is part of the ANO-2 RPS used to comply with the GDC 10 requirements.

In 10 CFR 50.36, "Technical specifications," the NRC established its regulatory requirements related to the content of TS. In accordance with the 10 CFR 50.36 requirements, TSs are required to include items in the following five specific categories related to station operation: (1) safety limits, limiting safety system settings, and limiting control settings; (2) LCOs; (3) surveillance requirements (SRs); (4) design features; and (5) administrative controls. The regulations in 10 CFR 50.36(c)(2)(ii)(C) specifies that a TS LCO must be established for a "structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier." Paragraph 50.36(c)(3) specifies that SRs are "requirements related to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met." Following these two provisions of 10 CFR 50.36, SRs for calibrations of RCS flow rates for CPC and COLSS indications are required as specified in FUNCTIONAL UNIT 10 and its associated Notes (7) and (8) of TS TABLE 4.3.1 to ensure the quality of the CPC DNBR trip functions. In this review, the NRC staff evaluates the effect that the change of the RCS flow measurement methods would have on the DNBR calculation in the CPC to assure that the ANO-2 would remain in compliance with the requirements of GDC 10 and 10 CFR 50.36.

3.0 TECHNICAL EVALUATION

The CPCs include a flow algorithm that determines a normalized mass flow rate with respect to the design mass flow rate from the speeds of the four RCPs, the specific volume of the primary reactor coolant and a correction based on RCS hot-leg temperature. A flow calibration constant (FC1) is included in the CPC flow algorithm to allow for calibration of the normalized mass flow rate against independent flow measurements. As for the COLSS, it has an algorithm that calculates RCS flow based on RCP head curves, RCP rotational speed, and RCS cold-leg temperature. Bias constants associated with the volumetric flow rate determined for each RCP are included in the COLSS algorithm to allow for calibration. In accordance with the monthly SRs specified in TS Table 4.3-1 Note (8), the COLSS indicated flow rate (initially based on the measured ΔP across RCPs) is verified conservative with respect to the calorimetric flow rate, and the CPC indicated flow rate is verified conservative with respect to the COLSS flow rate. COLSS flow bias constants and CPC flow constant (FC1) are changed, as necessary, to achieve the required relationship between indicated and measured flow rates. During shift surveillances associated with TS Table 4.3-1 Note (7), the CPC indicated flow rate is verified conservative with respect to either COLSS or calorimetric flow rate. The licensee indicated that the conservative (low) flow rate is typically a calorimetric flow rate.

The calorimetric flow method relies on RCS hot-leg temperature instrumentation and can be susceptible to temperature stratification effects. The temperature stratification in the RCS hot-legs could result in low calorimetric flow measurements and the associated calibration of COLSS and CPC indicated flow rates, which lead to a smaller power margin as applied to DNBR calculations in the CPC and COLSS. The licensee proposed TS changes to allow RCP ΔP-based flow rates, as calculated by the COLSS, to be used as the calibration standard at all surveillance intervals for RCS flow rates used in CPC and COLSS. In response to the NRC staff's requests for additional information (RAIs), the licensee provided information in References 2 through 4 related to a discussion of inaccuracy of calorimetric flow measurements and justification for use of the RCP ΔP instrumentation as the wholly independant method for RCS flow measurements. The NRC staff's review of the proposed TS changes in Reference 1 and the supporting information in References 2 through 4 is discussed in Section 3.1 for calorimetric flow measurements, Section 3.2 for RCP ΔP flow measurements and Section 3.3 for the proposed TS changes as follows.

3.1 Calorimetric Flow Measurements

Calorimetric flow measurements rely on the secondary calorimetric power, RCS cold-leg and hot-leg temperature measurements. The RCS hot-leg temperature instruments currently used in the calorimetric determination of RCS flow rates consist of eight temperature elements on each hot-leg. The eight temperature elements on each hot-leg are arranged in pairs of two, with two forming the pair being 90 degrees apart along the circumference of the pipe. On each hot-leg, three instrument pairs are positioned on the top half of the pipe and one instrument pair is positioned on the bottom of the pipe. The average temperature of the hot-leg coolant is determined by weighting instruments equally between the top and bottom of the pipe in accordance with the formula listed on page 2 of Reference 2. The temperature stratification in the RCS hot-legs could result in low calorimetric flow measurements and the associated calibration of COLSS and CPC indicated flow rates.

In response to RAIs, the licensee provided information of the hot-leg temperature stratification for Cycles 15 and 20 in Reference 2 and for Cycles 16 to 19 in Reference 3. For example, Figures 1A and 1B in Reference 3 show the stratification in Loop A and B hot-leg during Cycle 15. All the applicable figures in References 2 and 3 show that the temperatures measured at different locations around the hot-leg pipe are different significantly. As shown in Figures 2, 3, 5, and 6 of Reference 2, the most variation occurs in the hottest temperature indications. The variation in temperature measurements for the hot-leg coolant, a result from temperature stratification, was observed in many domestic PWRs. The licensee performed a sensitivity analysis of the RCS calorimetric flow rate to the hot-leg average temperature. The analysis was based on a simplified heat balance calculation with a cold-leg average temperature of 551 degrees Fahrenheit (°F), RCS pressure of 2200 pounds per square inch absolute (psia) and reactor power of 3026 megawatt thermal (the current rated thermal power). The results of the analysis in Table 2 of Reference 2 show that a 7 °F range of hot-leg average temperature could affect the calculated RCS flow by more than 13 percent of the design mass flow rate. The wide variation in RCS hot-leg temperature indications and associated sensitivity of the flow rate to the average hot-leg temperature show that calorimetric flow measurement lack precision.

In the response to RAI 1(b) in Reference 2, the licensee provided the results of an analysis that quantified the over-conservatism of RCS flow rate based on the calorimetric flow measurement method as compared to the RCP ΔP measurement method. As part of the analysis, the licensee calculated relative changes in flow indicated by RCP ΔP readings for nine cases and provided the results in Table 1 of Reference 2. The analysis was performed using a consistent set of RCP head curves for Cycles 1 through 3, 12 through 14, 15 (first cycle with replacement steam generators (RSGs)), 16 (first power uprate cycle), and 20 (one-half core with new generation fuel rods), corrected to a reference conditions of 545 °F and 2200 psia. The results in Table 1 show the flow rate of approximately 109.4 percent of the design mass flow rate (of 120.4 $\times 10^6$ pound mass/hour) for Cycles 1, 2, 3, and 12, and expected reductions in the RCS flow resulting from significant plugging of the original steam generator (OSG) tubes (Cycles 12 though 14) and the partial introduction of next generation fuel (NGF) in Cycle 20. The results also show the restoration of the flow rate following installation of RSGs to a level (110.1 percent of the design mass flow) matching or exceeding the plant original flow.

The licensee's calorimetric flow verification also shows that the full power RCP ΔP flow rates are adequately supported by both the flow rate (110.3 percent of the design mass flow rate) based on the calorimetric flow measurements performed for Cycles 1 and 2 (RAI 1(b), Reference 2), and an alternate measurement flow (113.4 percent of the design mass flow rate) based on ultrasonic flow measurements (RAI 2(a), Reference 2) performed as part of the Cycle 1 startup test plan.

Cycle 15 is the first cycle installed with the RSGs. However, the licensee's calculations show that the full-power calorimetric flow rate (RAI 1(b), Reference 2) for Cycle 15 is 106.4 percent of the design mass flow rate based on hot-leg and cold-leg temperature data that were measured over the course of Cycle 15. In comparison with the calculated RCS flow rates in Table 1 of Reference 2, this drop in calorimetric flow rate from 110.3 percent to 106.4 percent of the design mass flow rate is inconsistent with the RCP ΔP indications (110.1 percent of the design mass flow rate) and design predictions of the flow rate (of approximate 109.4 percent of the design mass flow rate) following steam generator (SG) replacement. The RSGs are designed to provide greater heat transfer than the OSGs while essentially maintaining the original primary side flow resistance. This RCS flow comparison shows that the drop in the calorimetric flow rate is a result of a high average RCS temperature measurement caused by flow stratification effects. Considering uncertainty in the actual surface roughness of the OSG and RSG tubes, the licensee calculates that the Cycle 15 calorimetric flow rate is lower than the best estimate predicted flow rate by at least 3 percent (RAI 8, Reference 3) of the design mass flow rate. Considering RSG tolerances at the extreme levels, producing the predicted minimum flow, the Cycle 15 calorimetric flow rate is lower by at least 2 percent (RAI 8, Reference 3) of the design mass flow rate. Furthermore, the licensee estimates that on average, a 1 percent change in RCS flow rate corresponds to approximately 3/4 percent change in power margin as applied to the DNBR calculations in COLSS and CPC (RAI 1(b), Reference 2).

3.2 RCP ΔP Flow Measurements

To reduce the over-conservatism in the RCS flow rate determination using calorimetric measurements, the licensee proposed to use the COLSS indicated flow rate calculated from RCP ΔP flow measurements as a wholly independent calibration method over entire operating temperature and pressure range for an extended period of the RCP operation time. The RCS flow rate based on RCP ΔP measurements is determined using RCP head curves, which are developed on a specific testing configuration, temperature, and pressure conditions. COLSS flow calibrations using temperatures and pressures out of the RCP testing conditions may lead to inaccurate RCS flow rate determination. In addition, the licensee did not provide plant data or analysis to support that RCP head degradation would not occur for an extended period of operation. During the course of the review, the NRC staff requested the licensee to provide justification for the adequacy of use of the RCP ΔP measurements for RCS flow rate determination. In response, the licensee provided the information, including constancy of RCP ΔP instrumentation, RCP ΔP flow uncertainty analysis, and validation of Cycle 1 and 2 calorimetric flow measurements for the NRC staff to review. The NRC staff's review of each area is discussed in respective Sections 3.2.1, 3.2.2 and 3.2.3 as follows.

3.2.1 Constancy of RCP ΔP Instrumentation

The licensee provided RCP ΔP data from Cycle 15 to Cycle 19 in Figure 1 of Reference 2 to support its position that the RCP head curves will not degrade for an extended period of operating time. Subsequently, in response to the NRC staff's second RAI, the licensee expanded to include all available RCP ΔP data covering Cycles 3 through 20 in Figure 7 of Reference 3. The NRC staff noted that the data presented showed evidence of RCP ΔP perturbations. In its response to RAI 5 (Reference 3), the licensee explained that the ΔP perturbations were the results of instrument errors or SG modifications. For example, the earlier data as shown in Figure 7 of Reference 3 were largely affected by the increase in SG tube plugging with occasional obvious calibration problems (between Cycles 5 and 6) and instrument hardware problems (one instrument in particular between Cycle 9 and 10). Significant improvements to the RCS ΔP flow calibration procedure took place after Cycle 8. Static pressure biases were taken into account during calibrations from Cycle 9 forward and consistency of instrument performance appeared to improve as a result. The CPD6176A performance in Cycle 10 was subject to a hardware problem that was corrected mid-way through the cycle.

There are two instruments used for each RCP for ΔP measurements, CPD61x6A and CPD61x6B, where "A" and "B" for a given indication are independent measurements (aside from sharing a common pressure tap) of the ΔP across the same pump ("x" can be 6 or 7 or 8 or 9, for the four pumps). The NRC staff noted that for Cycles 16 to 19, the ΔP readings of CPD6196A and CPD6196B changed significantly from cycle to cycle and for Cycles 15 to 18, the ΔP readings of CPD6196A are significantly different from that of CPD6196B. With respect to the CPD6196A and B observations, the licensee explained that these were indicative of instrumentation problems affecting both the primary and backup ("A" and "B") instruments for the same pump, not pump performance degradation. In particular, the instrument supplying the CPD6196A indication was affected by isolation valve leakage that prevented accurate calibration from at least the middle of Cycle 16 until isolation valves were replaced after Cycle 17. The CPD6196B indication was affected by a bad transmitter prior to transmitter replacement after Cycle 16. The instrument performed as expected through Cycle 16 until calibrations were performed near the end of Cycle 17. Maintenance records indicated that near the end of Cycle 17, the transmitter calibration was adjusted while at system pressure for unknown reasons. The licensee stated that the transmitter calibration near the end of Cycle 17 resulted in an erroneous calibration. Correction of these issues has led to normal operation of these indications for the most recent Cycles 19 and 20.

As a result of these observations, the licensee established the following surveillance criteria (RAI 1, Reference 3) for RCP ΔP and temperature instruments to ensure that RCS ΔP flow calibration errors are detected and addressed:

1. Verify that instrument quality indicated by the plant computer remains acceptable. Unacceptable or questionable instrument quality is monitored by COLSS cross checks of preferred (primary) and alternate (backup) instruments.

2. The RCP ΔP and RCS cold-leg temperature instrumentation for each cold-leg (preferred and alternate) are verified to remain constant with 1.0 pounds per square inch (psi) and 2.0 °F of each other, respectively.

3. At 100 percent power following refueling, average instrument readings are compared to equivalent readings from the previous cycle and verified to agree within 0.5 psi and 1.0 °F for the RCP ΔP and cold-leg temperature readings, respectively.

If the above deviations exceed the specified tolerances, the impact of the difference is evaluated based on a sensitivity of 0.30 percent flow/psi for RCP ΔP readings and 0.07 percent flow/°F for average temperature readings. If non-conservative deviations beyond the specified tolerances cannot be attributed to actual process changes, flow penalties are applied to reduce the COLSS indicated total flow rate. This is expected to reduce the CPC flow rate when calibrated to COLSS flow.

The NRC staff conducted a review of proprietary information regarding the derivations or bases for the following criteria used in the surveillance criteria at the Westinghouse Rockville office on July 20, 2009:

(1) 0.5 psi for cycle-to-cycle RCP ΔP readings
(2) 2.0 °F for temperature readings in each cold-leg
(3) 1.0 °F for cycle-to-cycle average temperature readings from cold-legs
(4) Penalty factor of 0.3 percent flow/psi for the RCP ΔP reading
(5) Penalty factor of 0.07 percent mass flow/°F for the cold-leg temperature reading

The NRC staff concludes that appropriate plant data were used in the calculations that applied the same methods used in support of current RCS ΔP flow measurements, and results for derivations of the above surveillance criteria were appropriately discussed and documented. Therefore, the NRC staff concludes that the surveillance criteria is acceptable.

Based on the above discussion, the NRC staff concludes that the licensee provided reasonable explanation for causes of the measured RCP ΔP perturbations, and that plant maintenances and surveillances with the acceptable surveillance criteria at ANO-2 would identify and correct instrument errors adequately, and reasonably ensure constancy of the RCP performance. Therefore, the staff concludes that this is acceptable.

In addition, the uncertainty analysis (RAI 5, Reference 3) for the proposed RCP ΔP method uses a ΔP instrument uncertainty based on a drift of ± 2.8 psi for the instrument span covering up to 22.5 month calibration interval. At ANO-2, calibrations are performed at an interval of about 18 months. The maximum "as found" errors observed during calibration performed since SG replacement (in Cycle 15) is 1.31 psi. Although these "as found" errors are a combination of drift, repeatability, and calibration errors, the NRC staff concludes that the "as found" errors reasonably support the conclusion that the ΔP instruments are performing within the bounds of uncertainties, for the conditions that hardware problems (such as the CPD6196 issues discussed above) do not exist that introduce a bias.

3.2.2 Uncertainty Analysis for RCP ΔP Flow Measurements at Temperatures and Pressures Conditions Outside RCP Test Conditions

In addressing the NRC staff's concern of the RCP ΔP flow calibrations performed at temperature and pressure outside the test conditions for which the RCP ΔP head curves were obtained, the licensee provided a discussion of an uncertainty analysis for the full operating temperature and pressure range in the RAI 2(b) response (Reference 2). At ANO-2, RCP head curve constants to be installed in COLSS were derived from the RCP vender test data. The vendor data were compiled at temperature and pressure conditions very close to normal operating temperature and pressure. The average test conditions were at 2202 psia and 557 °F, while at full power, the normal operating pressure and cold-leg temperature were 2200 psia and 551 °F. The vendor data were also compiled using a range of ΔPs that more than encompassed the ΔPs experienced during normal operation and observed with significant SG tube plugging in earlier cycles. The licensee performed supporting analyses that considered deviation of operating conditions from those at which the one-time COLSS calorimetric flow calibration was performed. The normal operating condition for calibration was at a pressure of 2200 psia and a cold-leg temperature of 551 °F. Simulations performed as part of the supporting analyses identified the sensitivity of the RCS flow with respect to a change of the RCS pressure and temperature that were listed in Table 3 of Reference 12. The corresponding uncertainty assumed in the analyses was used to establish an allowable deviation of ±50 psi and ±7 °F from normal conditions. Based on actual operating conditions, changes within these limits have negligible effect on the validity of the COLSS calibration relative to uncertainties of the instrumentation involved.

The design core inlet temperature program for ANO-2 varies the RCS cold-leg from 545 °F at zero power to 551 °F at full power. The RCS pressure is normally maintained within the above tolerance by pressurizer proportional heater controls. The proportional heater control setpoints are for zero heater output at 2225 psia and full power at 2175 psia. Therefore, the NRC staff concludes that the COLSS calibration will remain valid over the full range of normal operating conditions.

3.2.3 Validation of Cycle 1 and 2 Calorimetric Flow Measurements

In its response to RAI 2(c) (Reference 2), the licensee clarified that although both use RCP ΔP instrumentation, the uncertainty of the proposed COLSS flow measurement method is significantly different from the current COLSS flow measurement. The current COLSS flow indication relies on monthly calorimetric measurement of the reference flow and calibration of the COLSS flow to the reference flow. The proposed method relies on calibration of the COLSS flow to a single calorimetric based reference flow and no further adjustment. In support of use of the proposed COLSS flow measurement method, the licensee performed a one-time validation of calorimetric flow measurements (that are the reference flow rates for the proposed method) by reviewing calculations performed for Cycle 1 and 2 calorimetric flow measurements. The validation involved the licensee's review (RAI 2(a), Reference 2) of inputs for those calorimetric flow measurements to ensure that the inputs were consistent with the documented uncertainties. The licensee repeated the calculations to verify the results. The measurements were also confirmed with alternate, independent ultrasonic flow measurement not affected by flow stratification. The results of the flow validation show that the full power RCS flow rate (110.3 percent of the design mass flow rate) based on the calorimetric flow measurements (RAI 1(b), Reference 2) is consistent with RCS flow rates based on RCPΔP measurements, and is also adequately supported by an alternate, independent measurement flow (113.4 percent of the design mass flow rate) based on ultrasonic flow measurements (RAI 2(a), Reference 2) performed as part of the Cycle 1 startup test.

In addition, the licensee performed (RAI 2(a), Reference 2) a cross-check of the proposed method's accuracy by back-calculating the average hot-leg temperature that would need to exist if the expected flow using the proposed RCP ΔP method were actually present. The back-calculation of hot-leg temperatures was performed assuming: (1) the flow rate was equal to the average of Cycle 1 and 2 calorimetric measurements; (2) actual Cycle 15 and 16 cold-leg temperature and pressure were used; (3) the flow was adjusted down by the predicted change in resistance from the OSGs to RSGs; and (4) the flow was reduced by the uncertainty (4.1 percent for TS monitoring) of the proposed pump proposed RCP ΔP method. The results are included in Figure 9 (Reference 2) that shows the back-calculated average hot-leg temperature against (1) the average of the coolest and most stable hot-leg temperature indications and (2) the individual hottest and most variable temperature indications. Figure 9 shows that, as expected, the real average hot-leg temperature would have to be lower than normal instrumentation averaging would indicate. It also shows that the predicted average hot-leg temperature, at one extreme of the method's uncertainty, bounds the coolest and least variable temperature indications by about 2 °F. Since the actual average hot-leg temperature should be constant during constant power operation, the hottest and most variable temperature indications are likely the least indicative of the actual average temperature. The back-calculation of the expected hot-leg temperature for the increased flow rate would provide some evidence that the actual flow rate is within the bands of the proposed method's uncertainty. Furthermore, the uncertainty of the proposed flow method applicable to safety analyses (5.8 percent for CPCs) is larger than that applied for TS monitoring. When the average hot-leg temperature is predicted at this higher uncertainty, it becomes approximately equal to or greater than the average temperature of all indications at the location of minimum stratification. The NRC staff concludes that this result provides reasonable assurance that the validated flow rate used in the CPC would be within uncertainty of the actual flow and that safe operation would be maintained.

The components of the uncertainty analysis (RAI 2(c), Reference 2) covering the proposed RCP ΔP method include the existing uncertainty components applicable to the calorimetric methods with inclusion of the following additional components: (1) ΔP instrument loop uncertainty with 22.5-month drift allowance to accommodate refueling interval calibrations; (2) an uncertainty allowance to account for the accuracy of the simulation that provides a basis for adjusting OSG based reference flow to RSG conditions; and (3) uncertainty to include observed variation of RCP ΔP and cold-leg inputs used in the COLSS calibration constant calculation. A summary of the uncertainties for the proposed RCP ΔP method is included in Table 4 of Reference 2.

The NRC staff conducted a review of proprietary information regarding the derivations for the following Table 4 uncertainties it used in safety analysis or TS flow monitoring at the Westinghouse Rockville office on July 20, 2009:

(1) ±5.2 percent and ±5.8 percent for the COLSS volumetric flow uncertainty and CPC mass flow uncertainty used in the safety analysis, respectively, and

(2) 4.1 percent and 2.9 percent for the COLSS mass flow uncertainty and the reference mass flow uncertainty used for TS monitoring of the RCS flow rates, respectively.

The NRC staff concludes that appropriate plant data were used in the uncertainty analysis, and the components of the uncertainty analysis were statistically combined in accordance with the NRC-approved method documented in a report, CEN-356(V)-P-A. Therefore, the NRC staff concludes that the uncertainties listed in items (1) and (2) above are acceptable.

3.3 Technical Specification Changes

Current ANO-2 TS 3.3.1.1, Reactor Protective Instrumentation, Table 4.3-1 specifies periodical RCS flow verification associated with FUNCTIONAL UNIT 10, DNBR-Low, in accordance with the associated Notes (7) and (8).

Current Note (7) for shiftly flow verification requirements states that:

> Above 70% RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the actual RCS total flow rate determined by either using the reactor coolant pump differential pressure instrumentation (conservatively compensate for measurement uncertainties) or by calorimetric calculations (conservatively compensated for measurement uncertainties) and if necessary, adjust the CPC addressable constant flow coefficients such that each CPC indicated flow is less than or equal to the actual flow rate. The flow measurement uncertainty may be included in the BERR1 term in the CPC and is equal to or greater than 4%.

Note (8) for monthly flow verification requirements states that:

> Above 70% RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the actual RCS total flow rate determined by calorimetric calculations (conservatively compensated for measurement uncertainties).

The proposed TS changes will delete the monthly RCS flow verification required for Functional Unit 10 in TS Table 4.3-1, and Note (8) associated with this monthly SR. The changes will combine the current shiftly and monthly RCS flow verification into one SR to be performed on a once per shift basis. In addition, the TS changes will revise Note (7) as follows:

> Above 70% RATED THERMAL POWER, verify that the total RCS flow rate as indicated by each CPC is less than or equal to the RCS total flow rate determined by either using the reactor coolant pump differential pressure instrumentation or by calorimetric calculations and, if necessary, adjust the CPC flow calibration addressable constant FC1 such that each CPC indicated flow is less than or equal to the measured flow rate.

As required by the proposed Note (7) to TS Table 4.3-1, the CPC flow verifications will continue to take place on a 12-hour interval, normally using the COLSS RCP ΔP flow measurement when available, and using the calorimetric flow measurement when COLSS is not available. The NRC staff concludes that this portion of the Note (7) changes and deletion of Note (8) associated with the monthly CPC flow verification based on the calorimetric calculations are adequately supported by the acceptable analyses discussed in Section 3.2 of this safety evaluation (SE) and, therefore, are acceptable.

The proposed Note (7) also states that the verification is performed using measured flow instead of actual flow. The CPC flow measurement uncertainty is included in the calculation of the CPC DNBR uncertainty addressable constant BERR1 based on the methodologies discussed in the NRC-approved topical report, CEN-356 (V)-P-A Revision 01-P-A, "Modified Statistical Combination of Uncertainties," dated May 1988. The NRC staff concludes that it is appropriate to verify that the RCS total flow as indicated in each CPC is less than or equal to the measured flow instead of the actual total flow rate. Therefore, the staff concludes that this portion of the TS changes is for clarification and is editorial in nature and, therefore, is acceptable.

As a result of the proposed TS changes, the reference to the flow measurement uncertainty is relocated from Note (7) to the associated TS Bases. This portion of the changes involves relocation of reference to the BERR1 uncertainty addressable constant from Note (7) to TS BASES 3/4.3.1 and 3/4.3.2, which state, in part, that:

> Uncertainties associated with measuring the flow rate are included in the determination of CPC DNBR uncertainty addressable constant BERR1 (using methodology described in CEN-356(V)-P-A). Separate BERR1 constants may be determined for COLSS and calorimetric methods. As applicable, the flow measurement uncertainty accounts for process and instrumentation uncertainties as well as uncertainties associated with calibration of the COLSS flow measurement algorithm based on pump casing curves, validated calorimetric flow measurements and detailed simulations of RCS flow.

The NRC staff concludes that the cited portion of TS BASES 3/4.3.1 and 3/4.3.2 adequately includes a discussion of the BERR1 uncertainty addressable constant accounted for the flow measurement uncertainty in the CPC DNBR calculation. Since the proposed relocation of the reference to the flow measurement uncertainty from Note (7) to the associated TS Bases does not reduce the TS requirements, the NRC staff concludes that this portion of the TS changes is acceptable.

In the proposed Note (7), reference to the CPC flow adjustment addressable constant FC1 is added. Since the FC1 is directly applicable to performance of the calibration to the measured flow, the NRC staff concludes that the change to add FC1 to Note (7) is an editorial change for clarification, does not change the TS requirements and, therefore, is acceptable.

3.4 Regulatory Commitment

TS 3.2.5 requires the RCS flow to be measured to ensure that the minimum initial flow assumed in safety analyses is available. TS 3.2.5 does not specify a measurement method to be used in meeting the SR. In response to the RAI, the licensee committed (Reference 4) that:

> Revise the bases of ANO-2 TS 3.2.5 to list the methods that could be used to measure RCS flow.

The licensee has scheduled to complete this commitment within 90 days of the approval of the request to modify RCS flow verification. The NRC staff concludes that the proposed commitment satisfies the need for continuing compliance and, therefore, is acceptable.

3.5 <u>SUMMARY</u>

At ANO-2, the licensee proposed to use the COLSS indicated flow rate determined from RCP ΔP flow measurements as a wholly independent calibration method over entire operating temperature and pressure range for an extended period of the RCP operation time. The NRC staff concludes that the proposed RCS flow verification method for use in the CPC and COLSS for DNBR calculations is acceptable based on: (1) inaccurate calorimetric flow measurements discussed in Section 3.1 of this SE; (2) the connection of recent and original flow rates based on RCP ΔP instrumentation discussed in Section 3.1; (3) constancy of RCP ΔP instrumentation discussed in Section 3.2.1; (4) the validation of Cycle 1 and 2 calorimetric flow measurements discussed in Section 3.2.3; and (5) the uncertainty analysis discussed in Sections 3.2.2 and 3.2.3. The NRC staff also concludes that the proposed changes to TS Table 4.3-1 and associated Notes (7) and (8) discussed in Section 3.3 for ANO-2 adequately reflect the acceptable SRs of the RCS flow verification for the CPC and COLSS discussed in Section 3.2. Thus, the NRC staff concludes that there is reasonable assurance that the proposed TS changes will provide adequate SRs to protect fuel rods from failure in meeting the GDC requirements regarding SAFDLs, and satisfying the 10 CFR 50.36 requirements regarding SRs in assuring safe operation of ANO-2.

Based on the above evaluations, the NRC staff concludes that the proposed changes to the SRs in TABLE 4.3-1 in the TSs were acceptable and meet 10 CFR 50.36. Therefore, the NRC staff concludes that the proposed TS changes are acceptable.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Arkansas State official was notified of the proposed issuance of the amendment. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendment changes a requirement with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20. The NRC staff has determined that the amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendment involves no significant hazards consideration, and there has been no public comment on such finding published in the *Federal Register* on January 27, 2009 (74 FR 4769). Accordingly, the amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

7.0 REFERENCES

1. T. Mitchell, Entergy Operations, Inc., Letter to U.S. Nuclear Regulatory Commission, "License Amendment Request, Technical Specification Change to Modify RCS Flow Verification, Arkansas Nuclear One, Unit 2, Docket No. 50-368, License No. NPF-6," dated November 13, 2009 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML083300364).

2. B. L. Berryman, Entergy Operations, Inc., Letter to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information for the Technical Specification Change to Modify RCS Flow Verification, Arkansas Nuclear One, Unit 2, Docket No. 50-368, License No. NPF-6," dated June 1, 2009 (ADAMS Accession No. ML091560026).

3. B. L. Berryman, Entergy Operations, Inc., Letter to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information for the Technical Specification Change to Modify RCS Flow Verification, Arkansas Nuclear One, Unit 2, Docket No. 50-368, License No. NPF-6," dated July 14, 2009 (ADAMS Accession No. ML092050631).

4. K. T. Walsh, Entergy Operations, Inc., Letter to U.S. Nuclear Regulatory Commission, "Revise Technical Specification 3.2.5, Technical Specification Change to Modify RCS Flow Verification, Arkansas Nuclear One, Unit 2, Docket No. 50-368, License No. NPF-6," dated August 17, 2009 (ADAMS Accession No. ML092310298).

Principal Contributor: S. Sun

Date: September 16, 2009

September 16, 2009

Vice President, Operations
Arkansas Nuclear One
Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802

SUBJECT: ARKANSAS NUCLEAR ONE, UNIT NO. 2 - ISSUANCE OF AMENDMENT RE: TECHNICAL SPECIFICATION CHANGE TO MODIFY REACTOR COOLANT SYSTEM FLOW VERIFICATION (TAC NO. ME0125)

Dear Sir or Madam:

The Commission has issued the enclosed Amendment No. 286 to Renewed Facility Operating License No. NPF-6 for Arkansas Nuclear One, Unit No. 2 (ANO-2). The amendment consists of changes to the Technical Specifications (TSs) in response to your application dated November 13, 2008, as supplemented by letters dated June 1, July 14, and August 17, 2009.

The amendment modifies TS 3.3.1.1, Reactor Protective Instrumentation, specifically Table 4.3-1 and associated Notes 7 and 8, to clarify and streamline Reactor Coolant System flow verification requirements associated with the Departure from Nucleate Boiling Ratio reactor trip signal.

A copy of our related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

/RA/

N. Kaly Kalyanam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-368

Enclosures:
1. Amendment No. 286 to NPF-6
2. Safety Evaluation

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