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Richard L. Anderson
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10 CFR 50.90

2CAN101801

October 10, 2018

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Responses to the Request for Additional Information Regarding License Amendment Request to Update the Reactor Coolant System Pressure-Temperature Limits
Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6

Dear Sir or Madam:

Entergy Operations, Inc. (Entergy) submitted a license amendment request to revise the Arkansas Nuclear One, Unit 2 Technical Specifications (TSs) via Reference 1. The proposed changes would replace the current Pressure-Temperature limits, applicable to 32 Effective Full Power Years (EFPY), with new Pressure-Temperature limits applicable to 54 EFPY (approximately 60 calendar years).

The Nuclear Regulatory Commission has reviewed the subject request and determined additional information is needed to complete review of the application. The request for additional information was issued to ANO-2 in Reference 4.

The purpose of this submittal is to provide the information that was requested.

Based on a review of the material provided in this submittal and in Reference 3, Entergy has concluded the no significant hazards determination provided in Reference 1, does not need to be revised.

No new regulatory commitments are included in this amendment request.

In accordance with 10 CFR 50.91, Entergy is notifying the State of Arkansas of this amendment request by transmitting a copy of this letter and enclosure to the designated State Official.

If there are any questions or if additional information is needed, please contact Stephenie Pyle, Manager, Regulatory Assurance, at (479) 858-4704.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on October 10, 2018.

Sincerely,

ORIGINAL SIGNED BY RICHARD L. ANDERSON

RLA/dbb

Enclosure: Response to Request for Additional Information (RAI) – Reactor Coolant System Pressure-Temperature Limits

REFERENCES:

1. Entergy submittal to the NRC, "License Amendment Request Updating the Reactor Coolant System Pressure-Temperature Limits," dated November 20, 2017 (2CAN111702) (ML17326A387)

2. NRC to Entergy, "Request for Additional Information Regarding License Amendment Request to Update the Reactor Coolant System Pressure-Temperature Limits," dated May 10, 2018 (2CNA051801) (ML18129A425)

3. Entergy submittal to the NRC, "Responses to the Request for Additional Information Regarding License Amendment Request to Update the Reactor Coolant System Pressure-Temperature Limits," dated August 1, 2018 (2CAN081802) (ML18215A177)

4. NRC to Entergy, "Request for Additional Information (RAI) Regarding License Amendment Request to Update the Reactor Coolant System Pressure-Temperature Limits," dated September 11, 2018 (2CNA091801) (ML18263A148)

cc: Mr. Kriss M. Kennedy
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U. S. Nuclear Regulatory Commission
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Enclosure to

2CAN101801

Response to Request for Additional Information (RAI)

Reactor Coolant System Pressure-Temperature Limits

Response to Request for Additional Information (RAI)

Reactor Coolant System Pressure-Temperature Limits

By application dated November 20, 2017 (ML17326A387), Entergy Operations, Inc. (Entergy), submitted a license amendment request (LAR) to revise the Arkansas Nuclear One, Unit 2 (ANO-2) Technical Specifications (TSs) by replacing the current Reactor Coolant System (RCS) Pressure-Temperature (P-T) Limits, applicable to 32 Effective Full Power Years (EFPY), with new P-T limits applicable to 54 EFPY (approximately 60 calendar years). The U.S. Nuclear Regulatory Commission (NRC) staff has determined that the following additional information is needed in order to complete its review.

RAI-1 – Low Temperature Overpressure (LTOP) Peak Pressure Determination

Request:

On Page 9 of the RAI response dated August 1, 2018, the licensee states that in the LTOP analyses for the most limiting mass and energy addition events, the maximum inlet piping pressure drop was added to a pressure equal to 110 percent of the relief valve setpoint to obtain the peak transient pressure at the pressurizer location.

Please clarify the basis to support the licensee's determination that peak transient pressures are based on 110 percent of the relief valve setpoint plus a maximum piping pressure drop. The information provided should include the following:

- Use of RELAP5-Based Data

  The 3rd paragraph on Page 9 of the RAI response states, in part, that "The current mass and energy addition events used explicit LTOP relief valve upstream and downstream pressure values as a function of relief valve flow based on RELAP5."

  Please explain how the RELAP5-based pressures versus relief valve flow were used in the LTOP reanalyses for the mass and energy addition events. If the RELAP5-based pressure-flow data for both steam and liquid discharge were used in the peak pressure determination as an input to CENTS or RELAP5, please explain the criteria used to determine when to switch-over from the pressure-flow data for the steam discharge to the pressure-flow data for the liquid discharge. During the transition from the steam discharge to the liquid discharge, the discharge of the mixture of the steam and liquid may occur. Please discuss and justify how the RELAP5-based pressure-flow data were used in the LTOP for the discharge of the steam-liquid mixture.

  Entergy's response:

  The RELAP5 analysis provides best estimate inlet pressures, flowrates, and backpressure values for steam and water as described below. The CENTS analysis describes the use of these RELAP5 values for both the mass and energy event.

  The steam flow rates versus valve inlet pressure used are the conventional form for American Society of Mechanical Engineers (ASME) relief devices as described in Reference 1, NB-7512.1 (opening pressure), NB-7173 (opening profile), and NB-7513 (rated lift). The valve is assumed not to open until 3% above the set pressure (accounts for upper bound setpoint tolerance) at an initial flow rate of 30% of the rated flow. The RELAP5 analysis provides the rated steam flow for the LTOP relief valve at a 430 psig setpoint is 41.4 lbm/sec or 2,484 lbm/min.

To convert this flow rate to volumetric flow, the density resulting from either 1) compressing saturated steam at 417.4 °F to a condition of 487.7 psia, and 2) compressing saturated steam at 444.6 °F to a condition of 487.7 psia are compared.

The enthalpy of saturated steam at 417.4 °F is 1204.1 BTU/lbm and the enthalpy of saturated steam at 444.6 °F is 1205.8 BTU/lbm.

Using the constant enthalpy, the density of 'wet steam' at 1204.1 BTU/lbm and 487.7 psia is 1.0529 lbm/ft^3.

Using the constant enthalpy, the density of 'wet steam' at 1205.8 BTU/lbm and 487.7 psia is 1.0506 lbm/ft^3.

The minimum volumetric flow corresponds to the density of 1.0529 lbm/ft^3.

Volumetric flow = 2,484 lbm/min ÷ 1.0529 lbm/ft^3 * 7.481 gallons/ft^3 = 17,649 gpm

The Reactor Coolant Pump (RCP) start analysis value for rated steam flow is conservatively set at 17,000 gpm at 10% above the set pressure (487.7 psia).

Both steam and water discharge coefficient values and backpressure corrections used in the RELAP analysis were taken from the valve manufacturer's data.

The water flow rates versus valve inlet pressure are also in the conventional form used in ASME code analyses for peak pressure. The valve is assumed not to open until 3% above the set pressure (accounts for upper bound setpoint tolerance) at an initial flow rate of 30% of the rated flow. The analysis value for rated water flow should be as follows at 10% above the set pressure (487.7 psia). The analysis values are:

Rated Water Flow Analysis Values	
For transient initiated with 417.4 °F saturated water	1,856 gpm
For transient initiated with 444.6 °F saturated water	1,600 gpm

The maximum flow rates for steam are not a concern with regard to valve backpressure. However, the maximum flow rates for water with regard to valve backpressure are as follows:

Maximum Flow Rates for Water	
For transient initiated with 417.4 °F saturated water	1,723.5 gpm
For transient initiated with 444.6 °F saturated water	1,416.5 gpm

The applicability of these values was also confirmed for a maximum backpressure of 223.2 psia assuming a relief valve lift at the lower setpoint tolerance of 417.1 psig (430 psig - 3%).

Use of RELAP5-based pressures versus relief valve flow in the LTOP energy addition event analysis

CENTS code input was designed to adjust the relief valve setpoints such that valve opening would occur at a higher pressure than the valve opening pressure to account for pressure losses in the pressurizer relief lines. The adjustments are shown in Table 1.

Table 1: Relief Valve Setpoint Adjustments for CENTS

Fluid	Valve Position (%)	Unadjusted Pressure (psia)	Flowrate (gpm)	Density (lbm/ft^3)	Relief Line DP (psid)[1]	Static Pressure (psia)[2]	Adjusted Setpoint (psia)
Water	0	444.7	0	51.206	1.74	5.40	451.84
	30	457.6	480.0	51.068	3.48	5.38	466.46
	100	487.7	1600	50.753	20.98	5.35	514.03
Steam	0	444.7	0	0.95717	0.03	0.00	444.73
	30	457.6	5100	0.9851	3.83	0.00	461.43
	100	487.7	17000	1.0506	44.97	0.00	532.67

Notes:

(1) Differential pressure (DP) of the relief line piping from the pressurizer to the LTOP relief valve. This differential pressure includes losses due to elevation.

(2) Differential pressure from the mid-point of the pressurizer to the top of the pressurizer.

Use of RELAP5-based pressures versus relief valve flow in the LTOP mass addition event analysis

Mass addition event input also adjusted the relief valve performance such that valve opening would occur at a higher pressure than the valve opening pressure to account for pressure losses in the pressurizer relief lines. The smallest relieving capacity of the cases was analyzed. The adjustments are shown in Table 2.

Table 2: Relief Valve Setpoint Adjustments for the Mass Addition Event

Fluid	Unadjusted Pressure (psia)	Flowrate (gpm)	Relief Line DP (psid)	Adjusted Setpoint (psia)
Water	457.6	480	3.6	461.2
	464.1	899.5	8.2	472.3
	467	999.6	9.7	476.7
	473.2	1199.5	13.1	486.3
	487.7	1600	21.9	509.6

With respect to the criteria used to determine when to switch-over from the pressure-flow data for the steam discharge to the pressure-flow data for the liquid discharge, for the mass addition event, only the most adverse liquid pressure-flow data were used to determine the peak pressure.

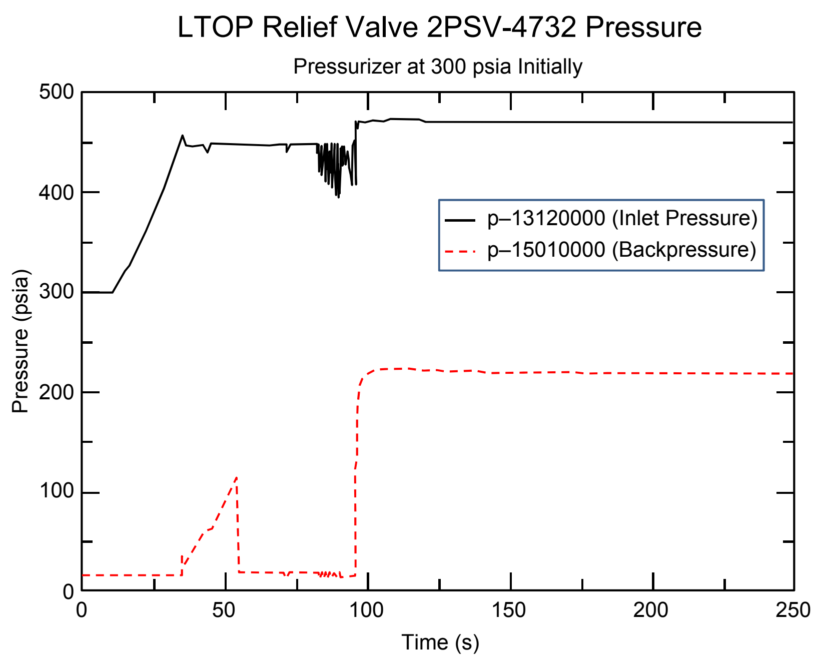
For the CENTS code energy addition event, controller logic was setup to read the tuned flow rates and adjusted setpoints, and monitor the quality through the valve. When the quality decreases to 0.95, the logic will switch from the steam flow area and setpoints to the water flow area and setpoints. A quality of 0.95 is chosen to conservatively switch to the lower capacity, higher setpoints, of the water relief characteristics.

With respect to how the RELAP5-based pressure-flow data were used in the LTOP for the discharge of the steam-liquid mixture:

In developing the RELAP5 pressure-flow data, the fluid in the pressurizer is compressed by an influx of fluid (at the initial pressurizer saturation temperature) through the pressurizer surge line. The LTOP relief valve starts to open at 3% overpressure (457.6 psia) of the valve's lift set pressure of 430 psig (444.7 psia). Initially, steam flow is discharged through the valve followed by a steam-water mixture, and finally water. The valve opens at about 35 seconds by discharging steam through the valve.

Subsequently, a two-phase mixture is discharged from about 82 seconds to 100 seconds followed by water. Peak inlet pressure occurs during water discharge. The valve inlet pressure and backpressure are shown in Figure 1. The relief valve flow versus backpressure characteristics are developed based on these RELAP5 pressurizer insurge evaluations including the relief valve developed backpressure and the effect of backpressure on pressure-flow data during the discharge of a two phase mixture. Initial pressurizer saturation temperatures corresponding to 300 psia and 400 psia were used to develop the pressure-flow data.

Figure 1: LTOP Valve Inlet Pressure and Backpressure



- Computer Code Used for the Reanalysis of the Mass Addition Event and the Calculated Peak Pressure

  Please identify: (1) the computer code (CENTS or RELAP5) used for the reanalysis of the mass addition event, and (2) the peak pressure from the calculation using CENTS or RELAP5 for the mass addition event. Also, please show that the calculated peak pressure is less than 110 percent of the relief valve setpoint.

  Entergy's response:

  The LTOP mass addition analysis provides best estimate relief valve flowrates and peak pressurizer pressure using the most adverse initial conditions for the event.

  The analysis of record method does not require the time dependent information provided by CENTS or RELAP5. The software used for the reanalysis of the mass addition event is Mathcad Version Prime 3.0. Documentation for the mass addition event is a Mathcad worksheet that shows detailed step-by-step descriptions and intermediate calculations, used in support of a design analysis performed and documented in accordance with the Westinghouse quality assurance program.

  The methodology used in the mass addition analysis is the equilibrium point approach to determining the peak transient pressure. This methodology assumes that sometime after the relief valve opens, an equilibrium between the mass input and valve discharge is achieved. The equilibrium pressure is determined at the intersection of the relief valve capacity curve with the mass input curve. In general, if the equilibrium pressure is less than the valve maximum opening pressure, then the peak pressure is assumed to equal the maximum opening pressure. Conversely, if the equilibrium pressure is above the maximum opening pressure, the former becomes the peak pressure. This is done to verify that the highest pressure that could occur will be utilized in the final analysis.

  The maximum pressure at the opening is herein identified as 10% overpressure, which is associated with the certified rated capacity. Also, as the ANO-2 specific reanalysis shows, the equilibrium pressure turns out to be less than 10% overpressure, and the equilibrium flow rate is less than the valve rated capacity. However, for conservatism, the peak pressure at the valve inlet is conservatively assumed to equal 10% overpressure.

  As stated in the above response to the first bullet of RAI-1, mass addition event input for the relief valve capacity curve adjusted the relief valve performance determined using RELAP5 such that valve opening would occur at a higher pressurizer pressure than the valve opening pressure to account for pressure losses in the pressurizer relief lines.

  With respect to illustrating that the calculated peak pressure is less than 110 percent of the relief valve setpoint, the LTOP mass addition analysis provides the best estimate relief valve flow rates and peak pressurizer pressure using the most adverse initial conditions for the event.

The peak calculated pressurizer pressure is 481.8 psia. The peak calculated pressure at the pressurizer relief valve inlet is 471.5 psia. The difference between the values of 481.8 psia and 471.5 represents the pressure loss within the inlet piping. 110 percent of the relief valve setpoint equals 487.7 psia.

With respect to the peak transient pressures being based on 110 percent of the relief valve setpoint plus a maximum piping pressure drop, the LTOP *mass addition* analysis provides best estimate relief valve flowrates and peak pressurizer pressure using the most adverse initial conditions for the event.

The peak calculated pressurizer pressure is 481.8 psia. The peak calculated pressure at the pressurizer relief valve inlet is 471.5 psia. The difference between the values of 481.8 psia and 471.5 represents the pressure loss within the inlet piping of 10.3 psid.

Consistent with the prior explanation of conservative analysis assumptions, the 10.3 psid is added to 110 percent of the relief valve setpoint or 487.7 psia resulting in an analysis peak transient pressure of 498 psia.

The LTOP *energy addition* analysis provides best estimate relief valve flowrates and peak pressurizer pressure using the most adverse initial conditions for the event.

The maximum relief line pressure drop based on the maximum flow of 536 gpm of water is calculated to be 9.8 psid (rounded up). The peak calculated pressurizer pressure is 466 psia.

Consistent with the prior explanation of conservative analysis assumptions, the 9.8 psid is added to 110 percent of the relief valve setpoint or 487.7 psia resulting in an analysis peak transient pressure of 497.5 psia.

The limiting 498 psia peak transient pressurizer pressure for the mass addition event is then compared to the 54 EFPY Reactor Coolant System Pressure-Temperature (RCS P-T) limits, as adjusted in the LTOP evaluation, to determine updated LTOP requirements.

- Maximum Inlet Pressure Drop Calculation

  The 4th paragraph on Page 9 of the RAI response states, in part, that “The relief valve inlet piping pressure drop was calculated based on this equilibrium flow rate.”

  Please justify that the “equilibrium flow” is the maximum flow and results in the maximum relief valve inlet piping pressure drop.

  <u>Entergy’s response:</u>

  The ANO-2 LTOP relief valves are spring loaded valves that have been demonstrated by the manufacturer to open proportionally to the inlet pressure at the valve. The valve opening is passive and is not reliant on pressure measurement instrumentation. The relief valve cannot open to an extent greater than that required to pass the transient generated flow because of its inherent mechanical design. The best estimate peak pressure and the maximum relief valve inlet pressure drop are evaluated at the maximum flow that is passed during the transient.

The condition at which the relief valve discharge equals the maximum flow that is developed during the transient is referred to as the “equilibrium flow.” The use of the most adverse initial conditions for the event, results in the maximum relief valve flow and therefore the maximum inlet piping pressure drop.

- Primary Temperature vs. Pressurizer Conditions

Please identify and justify Thot conditions that were used in the mass addition and energy addition analyses in combination with initial pressurizer saturation conditions corresponding to 300 pounds per square inch – absolute (psia) and 400 psia, respectively.

Entergy’s response:

The LTOP energy addition analysis and the LTOP mass addition analysis document the use an initiating event condition where a T_{hot} value corresponding to a T_{cold} equal to the LTOP enable temperature is used.

Choice of Temperature for Limiting Transient Pressure Results (both for initial pressurizer saturation conditions corresponding to 300 psia and 400 psia)

Design input for the initiating event conditions for mass addition and energy addition analyses were consistent with conditions for the LTOP entry temperature of 220 °F along with initial pressurizer saturation conditions corresponding to 300 psia and 400 psia.

The limiting energy addition event (RCP start event) is modeled using the CENTS code. It is assumed that the primary system T_{hot} is initially a few degrees higher than the LTOP enable temperature of 220 °F and that the Steam Generators (SGs) are filled with water at the limiting temperature of 100 °F above the primary system T_{hot}.

The LTOP mass addition event (one High Pressure Safety Injection pump and three Charging pumps) is also assumed to occur with the primary system initially at the LTOP enable temperature of 220 °F.

The choice of a temperature value equal to the LTOP enable temperature (defined in the TSs as cold leg temperature) minimizes the time between the pre-event full power operation and the time at which the initial temperature for the event is achieved. This is done in order to maximize decay heat which is a major source of heat for the energy addition event and a major source of coolant expansion for the mass addition event.

Based on a parametric assessment, it is confirmed that the peak transient pressures are reduced at lower T_{hot} temperature values.

- Energy Addition Transient Peak Pressure

Please identify the calculated peak pressure from the CENTS calculation for the energy addition event, and show that the peak pressure is less than 110 percent of the relief valve setpoint.

Entergy's response:

The LTOP energy addition analysis provides best estimate relief valve flowrates and peak pressurizer pressure using the most adverse initial conditions for the event.

The peak calculated pressurizer pressure from the CENTS calculation for the energy addition event is 466 psia. 110 percent of the relief valve setpoint equals 487.7 psia. Therefore, the peak calculated pressurizer pressure from the CENTS calculation for the energy addition event is less than 110 percent of the relief valve setpoint.

RAI-2 – Compliance with 10 CFR 50.36(c)(2)(ii)(B) for the Operating Limit of Steam Generator (SG) Water Temperature Assumed in the Analysis of the Limiting Energy Addition Event

Request:

Page 8 of the RAI response dated August 1, 2018, indicates that for the analyses of the most limiting mass and energy addition events, a maximum nominal pressurizer level of 910 cubic feet (ft^3) was assumed as an initial pressurizer water level during LTOP operation. The NRC staff notes that the operating limit of the pressurizer water volume of 910 ft^3 assumed in the LTOP analyses is included in a footnote to the APPLICABILITY of ANO-2 Technical Specification (TS) LCO 3.4.12, "Low Temperature Overpressure Protection."

Also, Page 11 of the RAI response states, in part, that the limiting energy addition event assumed that the SGs are filled with water at the initial temperature of 100 °F above the primary system T_{cold}. However, it is not clear whether this limitation is identified in the ANO-2 TSs.

Please identify the location in the ANO-2 TSs where the operating limit for the SG water temperature difference of 100 °F referenced above is specified and assumed as an initial condition in the LTOP analyses of the limiting energy addition event. If this limitation is not currently defined in TSs, please address compliance with the requirements of 10 CFR 50.36(c)(2)(ii)(B), Criterion 2, which requires inclusion of an LCO in TSs for plant process variables, design features, or operating restrictions that are used as an initial condition of a design transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier.

Entergy's response:

Accident and transient analyses described in the Safety Analysis Report (SAR) contain a significant number of inputs and assumptions that are not included in the TSs, yet are assumed to be met in order for the analysis results to remain within limits. As a matter practice, those variables, design features, or operating restrictions (Criterion 2) that are included in the TSs are those which can be readily exceeded without proper controls and verifications. The subject 100 °F temperature difference limit is a conservatively selected value that cannot reasonably be approached in LTOP applicability modes.

The Applicability note included in LTOP TS 3.4.12 was added in ANO-2 TS Amendment 242 (April 15, 2002, 2CNA040205, ML020870784) during a re-analysis of the LTOP protection capability. In Entergy letter dated October 30, 2001 (2CAN100101, ML013090073), this re-analysis required two additional actions (excerpt from October 30, 2001 letter, Attachment 1, Page 10):

> "…two additional operator actions need to be credited for the LTOP valve design which are reflected in the TS Bases. The credited operator actions are:
>
> 1) Operating restriction to assure two HPSI pumps are in pull-to-lock while LTOP conditions are enabled, and
> 2) Operating restriction to assure that the pressurizer water volume is less than 910 ft^3 when starting a reactor coolant pump."

(Note that these actions were subsequently added to the TS proper prior to NRC approval of ANO-2 TS Amendment 242)

While the subject 100 °F temperature difference limit was discussed in the correspondence, it was not considered a variable controlled by the operator. The 100 °F temperature difference limit is a conservative analysis assumption developed to reasonably bound the energy addition to the RCS during a start of the first RCP. This analytical assumption is not a condition that can reasonably exist in the actual plant. The two RCS loops, each containing one SG, are not isolable from one another; therefore, any forced or natural circulation flow through the RCS will maintain secondary water temperature within the SGs consistent with the existing RCS average temperature.

During shutdown conditions when LTOP requirements are applicable, the water inventory in each SG is supplied from condensate storage tanks (CSTs). The temperature of the water in the CSTs is maintained by ambient means during summer operations and by the auxiliary steam system or electric heaters during winter operations. The heating systems operate to control CST temperature between approximately 80 °F and 90 °F. In accordance with the RCS pressure and temperature limits of ANO-2 TS 3.4.9.1, the minimum bolt-up temperature of the reactor vessel head is 50 °F. Given that TS LTOP requirements are only applicable when the reactor vessel head is installed, the feedwater source for the SGs during LTOP conditions cannot reasonably rise above this minimum allowable RCS temperature by > 100 °F even during the hottest summer months.

In addition to the above, the inclusion of the subject 100 °F temperature difference limit would be inconsistent with restrictions and limits contained in the LTOP TS of NUREG 1432, "Standard Technical Specifications for Combustion Engineering Plants."

Based on the above, the 100 °F LTOP analysis assumption does not meet the intent of 10 CFR 50.36(c)(2)(ii)(B), Criterion 2, for inclusion in the TS. Therefore, Entergy does not propose the addition of this analysis assumption to the ANO-2 LTOP TS. Note that the 100 °F temperature difference assumption is currently discussed in the associated TS Bases for the LTOP TS:

> "The relief valves will be able to mitigate (1) the starting of the first reactor coolant pump when the pressurizer water volume is < 910 ft^3, and when the secondary water temperature of the steam generator is less than or equal to 100 °F above the RCS cold leg temperature (energy addition event), or (2) the simultaneous injection of one HPSI pump and all three charging pumps (mass addition event)."

REFERENCE

1. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Nuclear Power Plant Components, 1989.