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2CAN030201

March 13, 2002

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

SUBJECT: Arkansas Nuclear One, Unit 2
Docket No. 50-368
Response to NRC Request for Additional Information on ANO-2 Low Temperature Overpressure Protection

REFERENCES:

1 Entergy Letter dated October 30, 2001 (2CAN100101), "Proposed Technical Specification Change Request Regarding Revised ANO-2 Pressure/ Temperature and Low Temperature Overpressure Protection Limits for 32 Effective Full Power Years"

Dear Sir or Madam:

By letter dated October 30, 2001 (Reference 1), Entergy Operations, Inc. (Entergy) proposed a change to the Arkansas Nuclear One, Unit 2 (ANO-2) Technical Specifications (TSs) 3.4.9, Pressure/Temperature Limits and 3.4.12; Low Temperature Overpressure Protection (LTOP) Limits. The primary change being requested was to update the existing pressure/temperature (P/T) limits from 21 to 32 effective full power years (EFPY) and to include additional restrictions in the LTOP technical specifications.

Based on discussions between Entergy and Mr. Gene Hsii of your staff on January 29, 2002, a Request for Additional Information (RAI) was received from the NRC on January 30, 2002. Entergy's proposed response to the RAI was discussed with Mr. Hsii on March 4, 2002 and is contained in Attachment 1 of this letter.

In addition, Entergy is proposing to modify TS 3.4.12 from that previously proposed in Reference 1. The change involves the addition of a pressurizer water volume restriction prior to starting the first reactor coolant pump when in LTOP conditions. The original no significant hazards considerations included in Reference 1 is not affected by this additional restriction. There are no new commitments contained in this letter.

If you have any questions or require additional information, please contact Steve Bennett at 479-858-4626.

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I declare under penalty of perjury that the foregoing is true and correct. Executed on March 13, 2002.

Sincerely,

CGA/sab

Attachments:
1. Response to Request For Additional Information
2. Revised Markup of Technical Specification Pages

cc: Mr. Ellis W. Merschoff
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Attachment 1

To

2CAN030201

Response to Request for Additional Information

Response to Request for Additional Information Related to ANO-2 Low Temperature Overpressure Protection

Question 1:

For this proposed TS change with new pressure-temperature limits valid for 32 effective full power years, the peak transient pressure of the reactor coolant system (RCS) of 541.2 psia of the energy-addition event was based on previous low-temperature overpressure protection (LTOP) analysis performed for the replacement steam generator (Entergy letter no. 2CAN129907 to NRC dated December 21, 1999). That LTOP analysis was performed for (a.) the mass addition event with simultaneous injection of two HPSI pumps and all three charging pumps to a water solid RCS, and (b.) the energy addition transient with the start of an idle reactor coolant pump under water solid RCS conditions. Also, the analysis was based on the LTOP relief valve backpressure of 100 psig.

You have since identified a concern of higher backpressure on the pressurizer relief valve, compared to that assumed in the LTOP analysis due to potential flashing in the relief valve discharge line, and imposed two operating restrictions to address the concern:

Assure two HPSI pumps are in pull-to-lock while LTOP conditions are enabled, and,

Assure that the pressurizer water volume is less than 910 ft^3 when starting a reactor coolant pump.

Discuss how these two operating restrictions compensate for the increase in the relief valve backpressure relative to that assumed in the LTOP analysis of the mass-addition and energy-addition design basis events. The discussion should include: (a.) how the mass-addition and energy-addition design basis events were analyzed to verify the acceptability of the LTOP relief valve setpoint, (b.) the expected relief valve backpressure due to two-phase flow in the valve discharge line during the design basis transients, (c.) the effects of the increased relief valve backpressure on the relief valve discharge rate relative to the backpressure assumed in the analysis, (d.) how the restriction of one HPSI pump injecting into the RCS, compared to two HPSI pumps assumed in the analysis, compensates for the reduction In the relief valve discharge rate, and (e.) how the initial pressurizer void volume compared to the water solid assumption compensates for the reduced relief valve discharge rate.

ANO-2 Response:

The referenced LTOP transient analyses (energy –addition and mass-addition) accounted for such areas as RCS flow rates and steam generator parameters associated with the replacement steam generators and the decay heat due to uprate power. These analyses used the Technical Specification lift setpoint of 430 psig, a vent path size of 6.38 in^2, and an enable temperature of 220°F. The calculated peak pressure in the pressurizer for the energy addition event was determined to be 539.0 psia. For the mass addition transient the peak pressure is 522.2 psia. There is an additional 2.2 psid due to the reactor coolant flow into the pressurizer through the surge line to replace the inventory lost through the relief valve during the transient mitigation. Therefore the design peak pressure is 541.2 psia.

With the setpoint listed above, the peak pressure does not violate the proposed LTOP pressure/temperature limits.

The maximum relief valve discharge flow rate for the energy addition transient is 1977 gpm. The flow rate due to the mass addition transient is 1594 gpm. These flow rates were determined assuming valve characteristics with 100 psig of backpressure.

A concern was identified with the operation of the LTOP valves where the backpressure at the valve discharge is higher than originally expected. Increased backpressure reduces valve capacity for a given valve inlet pressure. New LTOP relief valve bellows are being installed in 2R15, which have a pressure rating to 500 psig. Of interest for the LTOP events is the valve capacity at a valve inlet pressure 10% above valve set pressure, since this is the maximum valve inlet pressure calculated to occur in the LTOP events.

The review of the backpressure impacts on the valve operation also established a maximum allowable backpressure. Operation of the valve was determined to be unstable when backpressure exceeded 50% of the set pressure. This limitation was found to restrict water flow through the valves to less than the values calculated for the LTOP events.

Consequently, operating restrictions must be established to limit the effects of the LTOP events such that the resulting flow through the valve produces a backpressure that is less than 50% of the set pressure. This flow must also be less than the capacity of the valve.

Given the replacement of the relief valve bellows, the following assumptions and conditions were made for the backpressure analysis:

- For water relief, the valves will not go into significant lift until about 8 to 9% over the set pressure, but once in significant lift, they will remain open until about 6% below the valve setpoint.

- For steam relief, the valves will go into significant lift very near the set pressure.

- The LTOP event volumetric flow rates that must be accommodated to assure RCS pressure remains acceptably low are on the order of 2000 gpm. If used to relieve steam at these volumetric rates, the capacity of the LTOP valves is more than sufficient. Also, steam release at these flow rates will not produce appreciable backpressure. Consequently, this analysis deals only with water relief capacity and backpressure considerations.

- The allowable range of setpoints for the LTOP valves is between 417 and 430 psig.

- The maximum RCS pressure while on shutdown cooling is 300 psia. This forms an upper limit for the pump start event. Before shutdown cooling is established (or after it is terminated) with RCPs in operation and with temperature below the LTOP enable limit of 220°F, it is possible (although remotely) that pressure could be as high as 400 psia. This analysis will consider the effects of this higher initial pressure on the mass addition event.

Flow Limits Due to Backpressure

The maximum LTOP valve backpressure limit is 50% of the set pressure. Since the valve set pressure can vary from 417 to 430 psig, the backpressure limit will vary from 208.5 to 215 psig or 223.2 to 229.7 psia. Backpressure values for a range of flow rates, water temperatures and valve inlet pressures were determined using RELAP 5, Mod 3.1. The results of this determination are provided below.

Pressure (psia)	Temperature (°F)	Flow (gpm)	Backpressure (psia)
487.7	445	1603	241
487.7	445	1202	201
473.4	445	1600	241
473.4	445	1200	201
487.7	417	1959	236
487.7	417	1498	204
473.4	417	2002	239
473.4	417	1601	211

The pressures 473.4 and 487.7 psia represent the valve inlet pressure at the 10% overpressure condition for valve setpoints of 417 and 430 psig, respectively. The temperatures of 417°F and 445°F are the saturation temperatures for pressurizer water at 300 psia and 400 psia, respectively, which are the maximum assumed starting pressures for the energy and mass addition LTOP events.

From these results, the flow limitation for each combination of valve inlet pressure and water temperature can be determined by interpolation. The resulting limits are:

Pressure (psia)	Backpressure Limit (psia)	Temperature (°F)	Flow Limit (gpm)
487.7	229.7	445	1490
473.4	223.2	445	1422
487.7	229.7	417	1869
473.4	223.2	417	1776

The flow rates determined in the original analyses of the LTOP events exceed these limits. Therefore, the analyzed events must be limited by additional operating restrictions.

Valve Capacity

The capacity of the valve is determined in the same manner as it was in the LTOP analyses. The capacity of the valve at 10% overpressure, with water temperature of 445°F and a backpressure of 230 psia was determined to be 6.74 E+5 lbm/hr. This mass flow rate is then converted to a volume flow in gpm. However, the methodology used determines the volume flow at the discharge of the valve. In this analysis the volume flow of water out of the pressurizer to the valve inlet is of concern. These flow conditions can be approximated using the pressurizer temperature of 445°F and the valve inlet pressure of 487.7 psia. At these conditions, the flow rate is 1623 gpm.

Valve inlet flow capacities at the other temperature and pressure conditions are calculated in the same manner. The resulting flow capacities are presented in the following table.

Pressure (psia)	Temperature (°F)	Mass Flow (lbm/hr)	Flow Capacity (gpm)
487.7	445	6.74 E+5	1623
473.4	445	6.49 E+5	1563
487.7	417	8.46 E+5	1991
473.4	417	8.13 E+5	1915

The valve capacities at 10% overpressure are compared to the flow limits due to backpressure in the following table.

Pressure (psia)	Temperature (°F)	Backpressure Flow Limit (gpm)	Flow Capacity (gpm)
487.7	445	1490	1623
473.4	445	1422	1563
487.7	417	1869	1991
473.4	417	1776	1915

This indicates that for this range of pressure and temperature conditions, the backpressure limit is reached before the valve capacity is exceeded. Consequently, if the flow rates from the LTOP events are reduced below the backpressure flow limits, they will also be less than the valve flow capacity.

Energy Addition Event

The energy addition event can produce a maximum flow rate of 1977 gpm through the LTOP valves at a valve inlet pressure of 472.7 psia. This flow rate is essentially independent of pressure at the LTOP valve. The flow rate from this event as currently analyzed would exceed the backpressure limit.

To resolve this concern, credit is taken for the steam space that exists in the pressurizer prior to starting the first RCP instead of assuming the pressurizer is water solid. This steam space can accommodate the initial expansion caused by the event. By the time the pressurizer is filled and the LTOP valve begins to pass water, the flow rate from the expansion will be well below the backpressure flow limit.

It was determined that the flow rate from the energy addition event would be less than about 1765 gpm at 15 seconds into the event. This is less than the minimum backpressure flow limit of 1776 gpm assuming the event started at pressurizer conditions of 300 psia and 417°F.

Assuming that a pressurizer maximum water inventory of 910 ft^3 is imposed, consistent with the existing Technical Specification in Modes 1 through 3 for pressurizer level, and using a nominal pressurizer water volume of 1200 ft^3, the pressurizer will have a steam space of 290 ft^3. Reducing this to account for instrument uncertainty, the steam space is conservatively calculated to be 170 ft^3 or 1270 gallons. Conservatively assuming the peak insurge flow rate of ~1980 gpm as a constant flow rate, the available steam space would not be filled for about 38 seconds. The flow rate would be less than 1000 gpm at this time.

Therefore, with the additional operating restriction to assure that the pressurizer water volume is less than 910 ft^3 when starting an RCP with no other pump running, the maximum flow through the LTOP valves from this event will be below the flow restrictions imposed by the backpressure limits.

Mass Addition Event

At equilibrium, the mass addition event can produce an injection flow rate of 1594 gpm through the LTOP valves at a valve inlet pressure of 467.5 psia. The flow rate would decrease slightly as pressure increased to the 10% overpressure values, but the mass addition event as it is currently analyzed would clearly exceed the backpressure flow limit.

To resolve this issue, this analysis credits the actions currently taken by Operations, which ensures that two of the three HPSI pumps are disabled (typically in Pull to Lock) when LTOP is required. This will then reduce the number of HPSI pumps assumed to start from two to only one.

A summary of the inputs assumed for the mass addition event is as follows.

RCS Pressure (psig)	Pressurizer Pressure (psia)	Flow Rate, gpm			
		2 HPSI Pumps	3 Charging Pumps	Additional Input	Total
0	5.8	1674	138	129	1941
200	205.8	1542	138	129	1809
400	405.8	1401	138	129	1668
600	605.8	1246	138	129	1513

This table is repeated below using the flow from one HPSI pump instead of two. The flow rates are increased by 5%.

RCS Pressure (psig)	Pressurizer Pressure (psia)	Flow Rate, gpm			
		1 HPSI Pump	3 Charging Pumps	Additional Input	Total
0	5.8	856	138	129	1123
200	205.8	789	138	129	1056
400	405.8	716	138	129	983
600	605.8	637	138	129	904

By inspection, it is clear that with the operating restriction to assure two HPSI pumps are in Pull to Lock while LTOP is enabled, the maximum flow from the mass addition event will be below the flow restrictions imposed by the backpressure limits.

CONCLUSIONS

With the operating restriction to assure that the pressurizer water volume is less than 910 ft^3 when starting an RCP with no other pumps running, the maximum liquid flow through the LTOP valves from the energy addition event will be less than 1000 gpm.

With the operating restriction to assure two of the three HPSI pumps are in disabled while LTOP is required, the maximum flow from the mass addition event will be less than 1000 gpm.

These LTOP valve flow rates are below the flow restrictions imposed by the backpressure limits and are well within the capacity of the LTOP valves, over the full range of allowable LTOP valve setpoints. With these limitations, the peak pressure values for the mass and energy addition events remain bounding.

As discussed above the current Technical Specification lift setpoint of 430 psig, a vent path size of 6.38 in^2, and an enable temperature of 220°F were used in the LTOP analyses. There are no changes proposed to these inputs. The analyses demonstrated the peak transient pressure is 541.2 psia. The above analysis demonstrated this value remains bounding for the existing backpressure. The LTOP pressure/temperature limits changed due to the recent vessel pressure/temperature work. The new minimum LTOP pressure/temperature limit is 607.7 psia using the K_{IC} methodology. Based on the above adequate LTOP protection is provided with the two operating restrictions.

RAI 2:

Since the restriction of the pressurizer water volume to less than 910 ft^3 when starting a reactor coolant pump is an initial condition in the energy-addition design basis event to comply with the pressure-temperature limits, why is this restriction not included in the LTOP limiting condition for operation (LCO) 3.4.12? Your answer should describe why this does or does not meet Title 10 of the Code of Federal Regulations Part 50.36(c)(2)(ii)(B) Criterion 2.

Response:

The previously proposed change to TS 3.4.12 (page 3/4 4-28) regarding the Low Temperature Overpressure Protection System is being further revised to include restrictions for pressurizer water volume prior to starting the first reactor coolant pump. A footnote is being added to the Applicability, which reads:

** - when starting the first reactor coolant pump, the pressurizer water volume will be < 910 ft^3.*

TS 3.4.12 was also modified to add "pump" to the LCO where it now reads:

The LTOP system shall be OPERABLE with each SIT isolated that is pressurized to ≥ 300 psig, and a maximum of one HPSI pump capable of injecting into the RCS and . . .

TS Bases 3/4.4.12 is also being clarified to state that the HPSI pumps will typically be placed in pull-to-lock to restrict flow into the RCS. Other minor clarifications to the Bases were also made to that previously provided in Reference 1. Attachment 2 contains the revised markup of TS 3.4.12 and it's associated Bases.

Attachment 2

To

2CAN030201

Revised Markup of Technical Specification and Bases Pages

REACTOR COOLANT SYSTEM

LOW TEMPERATURE OVERPRESSURE PROTECTION (LTOP) SYSTEM

LIMITING CONDITION FOR OPERATION

3.4.12 The LTOP system shall be OPERABLE with each SIT isolated that is pressurized to ≥ 300 psig, and a maximum of one HPSI pump capable of injecting into the RCS and:

a. Two LTOP relief valves with a lift setting of ≤ 430 psig, or

b. The Reactor Coolant System depressurized with an RCS vent path ≥ 6.38 square inches.

APPLICABILITY: MODE 4 with T_C ≤ 220°F, MODE 5, MODE 6 with reactor vessel head in place.*

ACTION:

a. With one LTOP relief valve inoperable in MODE 4, restore the inoperable valve to OPERABLE status within 7 days or depressurize and vent the RCS through a ≥ 6.38 square inch vent path within the next 8 hours.

b. With one LTOP relief valve inoperable in MODE 5 or 6, restore the inoperable relief valve to OPERABLE status within 24 hours or depressurize and vent the RCS through a ≥ 6.38 square inch vent path within the next 8 hours.

c. With both LTOP relief valves inoperable, depressurize and vent the RCS through a ≥ 6.38 square inch vent path within 8 hours.

d. With a SIT not isolated and pressurized to ≥ 300 psig, isolate the affected SIT within 1 hour. If the affected SIT is not isolated within 1 hour, either:

(1) Depressurize the SIT to < 300 psig within the next 12 hours, or

(2) Increase cold leg temperature to > 220°F within the next 12 hours.

e. With more than one HPSI pump capable of injecting into the RCS, immediately initiate action to verify a maximum of one HPSI pump capable of injecting into the RCS.

ef. The provisions of Specification 3.0.4 are not applicable.

* - when starting the first reactor coolant pump, the pressurizer water volume will be < 910 ft^3.

REACTOR COOLANT SYSTEM

BASES

3/4.4.12 LOW TEMPERATURE OVERPRESSURE PROTECTION SYSTEM

Low temperature overpressure protection (LTOP) of the RCS, including the reactor vessel, is provided by redundant relief valves on the pressurizer which discharge from a single discharge header. Each relief valve is isolated from the RCS by two motor operated block valves. Each LTOP relief valve is a direct action, spring-loaded relief valve, with orifice area of 6.38 in^2 and a lift setting of ≤ 430 psig, and is capable of protecting the RCS from overpressurization ~~when~~ from the limiting transient. The relief valves will be able to mitigate ~~is either~~ (1) the starting ~~of an idle~~of the first reactor coolant pump~~, under water-solid conditions~~ when the pressurizer water volume is < 910 ft^3, and ~~with~~ 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 ~~two~~ one HPSI pump~~s~~ and all three charging pumps. ~~to the water-solid RCS~~ (mass addition event). The action to prevent the capability of injection of more than one HPSI pump into the RCS will typically be accomplished by placing the HPSI pumps in pull-to-lock. The limiting LTOP design basis event is the energy addition event. The analyses assume that the safety injection tanks (SITs) are either isolated or depressurized such that they are unable to challenge the LTOP relief setpoints.

Since neither the LTOP relief valves nor the RCS vent is analyzed for the pressure transient produced from SIT injection, the LCO requires each SIT that is pressurized to ≥ 300 psig to be isolated. The isolated SITs must have their discharge valves closed and the associated MOV power supply breaker in the open position. The individual SITs may be unisolated when pressurized to < 300 psig. The associated instrumentation uncertainty is not included in the 300 psig value and therefore, the procedural value for unisolating the SITs with the LTOPs in service will be reduced.

The LTOP system, in combination with the RCS heatup and cooldown limitations of LCO 3.4.9.1 and ~~administrative~~ restrictions on RCP operation, provides assurance that the reactor vessel non-ductile fracture limits are not exceeded during the design basis event at low RCS temperatures. These non-ductile fracture limits are identified as LTOP pressure-temperature (P-T) limits, which were specifically developed to provide a basis for the LTOP system. These LTOP P-T limits, along with the LTOP enable temperature, were developed using guidance provided in ASME Code Section XI, Division 1, Code Case N-~~514~~ 641. This code case allows using an alternate means of determining LTOP P/T condition ~~that mandates that~~ but limits ~~"LTOP systems shall limit~~ the maximum pressure in the vessel to ~~110~~100% of the pressure ~~determined to satisfy Appendix G, paragraph G-2215 of Section XI, Division 1"~~ using the K1C approach allowed by the Code Case.

The enable temperature of the LTOP isolation valves is based on any RCS cold leg temperature reaching 220°F (including a 20°F uncertainty). Although each relief valve is capable of mitigating the design basis LTOP event, both LTOP relief valves are required to be OPERABLE below the enable temperature to meet the single failure criterion of NRC Branch Technical Position RSB 5-2, unless any RCS vent path of 6.38 in^2 (equivalent relief valve orifice area) or larger is maintained.