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Your ref: Docket No. 52-006 Our ref: DCP/NRC2409

March 23, 2009

Subject: AP1000 Responses to Requests for Additional Information (SRP 16)

Westinghouse is submitting responses to the NRC request for additional information (RAI) on SRP Section 16. These RAI responses are submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Responses are provided for the following RAIs:

RAI-SRP16-CTSB-54 RAI-SRP16-CTSB-55

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

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Robert Sisk, Manager Licensing and Customer Interface Regulatory Affairs and Standardization

### /Enclosure

1. Response to Request for Additional Information on SRP Section 16

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## ENCLOSURE 1

Response to Request for Additional Information on SRP Section 16

## **Response to Request For Additional Information (RAI)**

RAI Response Number: RAI-SRP16-CTSB-54 Revision: 0

#### **Question:**

TS 3.4.14 Low Temperature Overpressure Protection (LTOP) System

Explain an apparent inconsistency in the discussion of APPLICABLE SAFETY ANALYSES (SAS) in the TS bases B 3.4.14 regarding the Low Temperature Overpressure Protection (LTOP) system. Revise TS 3.4.14 and the associated Bases B 3.4.14, as appropriate.

In the sixth paragraph of the ASA, a restart of one reactor coolant pump (RCP) with water in the steam generator secondary side 50 degree F hotter than the primary side water when the RCS is in water solid condition is considered as a heat input transient.

The eighth paragraph of the ASA states "to prevent the possibility of a heat input transient, and thereby limit the required flow rate of the RNS suction relief valve, an administrative requirement has been imposed that does not allow an RCP to be started with the pressurizer water level above 92% and the RCS temperature above 200 degree F. Under these imposed conditions, the transient created by the startup of an RCP when the RCS temperature is above 200 degree F can be accommodated without additional pressure relief". The RCS water solid condition was not addressed by this administrative restriction. An additional restriction which states "No reactor coolant pump shall be started unless the secondary side water temperature of each SG is less than or equal to 50 degree F above each of the RCS cold leg temperatures" should have been imposed.

This information is needed to ensure LCO requirements reflect all plant conditions assumed in the accident analyses.

### Westinghouse Response:

As discussed in the response to RAI-SRP16-CTSB-55, LCO Note 2 was added to TS 3.4.14 and it includes a restriction on the steam generator to RCS temperature difference during an RCP start.

This RCP starting limitation already exists in TSs 3.4.4 and 3.4.8 for the RCS loops and minimum flow requirements, but was added to TS 3.4.14 for consistency and completeness. The Bases discussion was appropriately revised to reflect this change.

See the response to RAI-SRP16-CTSB-55 for the TS and Bases markups.



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## **Response to Request For Additional Information (RAI)**

Design Control Document (DCD) Revision:

None

PRA Revision:

None

## Technical Report (TR) Revision:

None



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## **Response to Request For Additional Information (RAI)**

RAI Response Number: RAI-SRP16-CTSB-55 Revision: 0

#### Question:

TS 3.4.4 Reactor Coolant System (RCS) Loops

Confirm that the temperature value of 200 degree F for RCS cold leg temperatures used in Note 3 of LCO 3.4.4 is the Low Temperature Overpressure Protection (LTOP) arming temperature specified in the PTLR.

AP1000 GTS 3.4.14 adopted the 275 degree F value. Another value of 200 degree F was proposed for use in AP1000 GTS 3.4.4 and 3.4.8 under Technical Report 74A, Revision 0.

This information is needed to ensure consistency of LTOP requirements specified in TS 3.4.4, TS 3.4.8, and TS 3.4.14.

#### Westinghouse Response:

#### <u>Overview</u>

The 200F limit for the minimum RCS temperature for requiring a pressurizer steam bubble when starting an RCP in LCO Note 3 of TS 3.4.4 has a different basis than the 275F RCS temperature limit for "arming" or implementing LTOP in TS 3.4.14.

Revision 0 of TR 74A implemented this 200F minimum RCS temperature limitation for requiring a pressurizer steam bubble while starting an RCP assumed in the LTOP analysis, as specified in the related LCO Notes for TSs 3.4.4, 3.4.8, and 3.4.14, for RNS equipment protection.

TR 74A did not change the LTOP implementation temperature of 275F specified in TS 3.4.14 of the TR for 10CFR50 Appendix G analysis reactor vessel protection.

An LTOP analysis update was completed to incorporate evolving design details related to the RNS suction relief valve inlet design pressure limit.

The re-analysis also now credits an existing technical design difference for AP1000 related to the variable-speed RCP start-up design limitations (RCPs are required to be started at a relatively slow pump speed and they are unable to start at full speed) not recognized in the Standard Technical Specification in NUREG-1431 (with conventional single-speed seal-RCP designs), and the AP1000 RCP start-up limitation was not credited in the previous AP1000 LTOP analyses.

As a result of crediting this reduced-speed RCP start-up limitation in this analysis update, the reanalysis now conservatively assumes water-solid RCS condition for RCP start-up at or below an



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### **Response to Request For Additional Information (RAI)**

RCS temperature of 350F in place of the previous 200F-limit for starting RCPs during watersolid operation for TSs 3.4.4, 3.4.8, and 3.4.14 as part of this RAI response. This change increases operational flexibility. Crediting the reduced-speed RCP start-up limitation, the LTOP Appendix G limits and the RNS piping and relief valve design limits are met for the limiting LTOP heat-input transient with water-solid RCS conditions at 350F or less.

The RCP start-up speed limitation and the change in the water-solid startup temperature limit are now incorporated into the associated TS LCO Notes as discussed below and in the related response for RAI-SRP16-CTSB-54.

LTOP Analysis Background Information

TS 3.4.14 establishes the LTOP alignment temperature of 275°F for AP1000 as a result of the 10CFR50 Appendix G analyses to protect the limiting reactor vessel location from overpressurization during low-RCS-temperature mass-input and heat-input events. This is discussed in the Bases for TS 3.4.14.

Reference to LTOP "arming" is typically associated with currently operating plants that electronically re-configure their pressurizer power-operated relief valves with a different (lower) RCS pressure actuation set point to provide LTOP for that plant.

The Applicability for TS 3.4.14 requires LTOP when the RCS is below a cold leg temperature of 275F in Mode 4, based on Appendix G requirements.

For AP1000, LTOP is implemented by aligning the RNS suction relief valve to the RCS (or by opening an RCS vent path once the RCS is depressurized in cold shutdown). The PTLR limits protected by the RNS relief valves (or an RCS vent path), which are shown in DCD Figures 5.3-2 and 5.3-3, were developed in accordance with the Appendix G analyses.

The RNS suction relief valve is aligned to the RCS by opening two series RNS suction line isolation valves connected to the bottom of the RCS hot leg. RNS is normally maintained aligned to the RCS and operating to provide RCS cooling during a plant cooldown below an RCS temperature of 350F. RNS can remain aligned to the RCS in standby (available to start an RNS pump and provide shutdown cooling if required) during a plant heatup until about 350F.

Therefore, the normal anticipated RNS alignment and operating procedures during shutdown plant conditions inherently satisfy the 275F LTOP implementation requirement, but the LTOP requirements of TS 3.4.14 preclude isolation of RNS below this LTOP implementation temperature.

When the RNS is aligned to provide LTOP, the RNS is subject to the same mass-input and heat-input overpressure transients as the RCS and, therefore, the RNS and its associated



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## **Response to Request For Additional Information (RAI)**

components must also be protected from overpressurization limits that are different from the Appendix G limits. Heat-input events are limiting for the RNS.

Therefore, the LTOP overpressure transient analyses evaluate potential overpressurization of the RNS to more than 110% of the system design pressure, as discussed in the Applicable Safety Analyses section of the Bases for TS 3.4.14, under RNS Suction Relief Valve Performance.

Since the start-up of an RCP is an initiating heat-input event requiring LTOP, the LCO Notes related to RCP start-up in TSs 3.4.4 and 3.4.8 are coordinated with the associated LTOP LCO Note in TS 3.4.14 for consistency and ease of operator use. The heat-input event considerations in the LCO Notes for these three TSs include RCP start-up, whether solid-plant conditions or a pressurizer steam bubble exists, the RCS temperature, and the steam generator to RCS cold leg temperature difference. These conditions are inputs to the LTOP analysis that establishes the LTOP relief valve capacity and setpoint.

As part of the evolving RNS relief valve design details to support valve design specification development and during associated procurement discussions with the valve vendor, it was determined that while the RNS relief valve piping and body design pressure are the same as RCS piping pressure (design to 2485 psig), establishing a relatively low LTOP relief valve pressure set point (500 psig) also requires a somewhat lower valve inlet pressure design limitation than the associated piping design pressure to protect relief valve components that must function at this significantly lower pressure set point.

Therefore, the LTOP analysis was updated to reflect this recently-identified valve component design limit.

#### Technical Specification LCO Note Changes

The TS 3.4.14 Bases discussion under RNS Suction Relief Valve Performance in the Applicable Safety Analyses was updated to include the additional LTOP consideration for acceptable RNS relief valve inlet pressure, as well as in the LCO Note Bases discussions for TSs 3.4.4 and 3.4.8.

LCO Note 2 was added to TS 3.4.14 to reflect the LTOP-related RCP starting limitations in TSs 3.4.4 and 3.4.8 for RCS loops and flow.

The LCO Notes for TS 3.4.4, 3.4.8, and 3.4.14 are also being revised to reflect the new RCS temperature limit of 350F.

The existing LCO Note (now revised to be Note 1) in TS 3.4.14 is being revised to be identically phrased to the corresponding LCO Notes in TSs 3.4.4 and 3.4.8. This eliminates potential confusion due to their wording differences for the same requirement.



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## **Response to Request For Additional Information (RAI)**

Also see the response to RAI-SRP16-CTSB-54 for related information on AP1000 LTOP.

## **Design Control Document (DCD) Revision:**

See the attached markup of TS 3.4.4, 3.4.8, and 3.4.14 LCO Notes and Bases Discussion.

### **PRA Revision:**

None

## Technical Report (TR) Revision:

None



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## **Response to Request For Additional Information (RAI)**

4 REACTOR CO	DLANT SYSTEM (RCS)
4.4 RCS Loops	
CO 3.4.4	Two RCS loops shall be OPERABLE and in operation (Four Reactor Coolant Pumps (RCPs) operating with variable speed control bypassed).
	- NOTES -
	1. No RCP shall be started when the reactor trip breakers are closed.
	<ol> <li>No RCP shall be started when the RCS temperature is ≥ 200350°F unless pressurizer level is &lt; 92%.</li> </ol>
	<ol> <li>No RCP shall be started with any RCS cold leg temperature ≤ 200350°F unless the secondary side water temperature of each steam generator (SG) is ≤ 50°F above each of the RCS cold leg temperatures and the RCP is started at ≤ 25% of RCP speed.</li> </ol>
· .	<ol> <li>All RCPs may be de-energized in MODE 3, 4, or 5 for ≤ 1 hour per 8 hour period provided:</li> </ol>
	<ul> <li>No operations are permitted that would cause introduction into the RCS, coolant with boron concentration less than required to meet the SDM of LCO 3.1.1; and</li> </ul>
	<ul> <li>Core outlet temperature is maintained at least 10°F below saturation temperature.</li> </ul>

ACTIONS

	CONDITION		REQUIRED ACTION	COMPLETION TIME
A.	- NOTE -	A.1	Be in MODE 3 with the reactor trip breakers open.	6 hours
	Required Action A.1 must be completed whenever Condition A is entered.			: .
	Requirements of LCO not met in MODE 1 or 2.			•

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### **Response to Request For Additional Information (RAI)**

Minimum RCS Flow 3.4.8

#### 3.4 REACTOR COOLANT SYSTEM (RCS)

- 3.4.8 Minimum RCS Flow
- LCO 3.4.8 At least one Reactor Coolant Pump (RCP) shall be in operation with a total flow through the core of at least 3,000 gpm.

#### - NOTES -

- All RCPs may be de-energized for ≤ 1 hour per 8 hour period provided:
  - a. No operations are permitted that would cause introduction into the RCS, coolant with boron concentration less than required to meet the SDM of LCO 3.1.1; and
  - b. Core outlet temperature is maintained at least 10°F below saturation temperature.
- 2. No RCP shall be started when the RCS temperature is ≥ 200350°F unless pressurizer level is < 92%.
- No RCP shall be started with any RCS cold leg temperature ≤ 200350°F unless the secondary side water temperature of each steam generator (SG) is ≤ 50°F above each of the RCS cold leg temperatures and the RCP is started at ≤ 25% of RCP speed.
- APPLICABILITY:

MODES 3, 4, and 5, whenever the reactor trip breakers are open and with unborated water sources not isolated from the RCS.

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ACTIONS		
CONDITION	REQUIRED ACTION	COMPLETION TIME
A. No RCP in operation.	A.1 Isolate all sources of unborated water.	1 hour
	AND	
	A.2 Perform SR 3.1.1.1, (SDM verification).	1 hour

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## **Response to Request For Additional Information (RAI)**

LTOP System 3.4.14

#### 3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.1	4 Low Temperat	ture Overp	ressure	Protection (LTOP) Syste	m.	• *
LCO 3.4.14		At least one of the following Overpressure Protection Systems shall be OPERABLE, with the accumulators isolated:				
		a. The valve		Residual Heat Removal	System	(RNS) suction relief
		b. The	RCS de	pressurized and an RCS	vent o	f≥4.15 square inches.
				- NOTE -		
			iless pre IO°F, a r	hall be started when the pssurizer level is < 92%. eactor coolant pump (RC or level is ≥ 92%.	When th	he RCS temperature is ≥
		 ter of	ld leg te mperatu		ss the s itor (SC	econdary side water
APPI	LICABILITY	MODE 5,		ny cold leg temperature is e reactor vessel head is		°F,
		greater th	an or e	- NOTE - ation is only required whe qual to the maximum RC ure allowed by the P/T lin	en accu S press	sure for the existing RCS
ACT	IONS					.' .
	CONDITIO	N		REQUIRED ACTION		COMPLETION TIME
Α.	An accumulato isolated when t accumulator pr	he essure is	<b>A.1</b>	Isolate affected accumulator.		1 hour

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### **RCS Loops** B 3.4.4 BASES APPLICABLE SAFETY ANALYSES (continued) Therefore, in MODE 3, 4 or 5 with the RTBs in the closed position and the PLS capable of rod withdrawal, accidental control rod withdrawal from subcritical is postulated and requires the RCPs to be OPERABLE and in operation to ensure that the accident analysis limits are met. In MODES 3, 4 and 5 with the RTBs open, RCS circulation is considered in the determination of the time available for mitigation of the accidental boron dilution event. This is addressed in LCO 3.4.8, "Minimum RCS Flow ' RCS Loops satisfy Criteria 2 and 3 of 10 CFR 50.36(c)(2)(ii). LCO The purpose of this LCO is to require an adequate forced flow rate for core heat removal. Flow is represented by the number of RCPs in operation for removal of heat by the SGs. To meet safety analysis acceptance criteria for DNB, four pumps are required in MODES 1 and 2. The requirement that at least four RCPs must be operating in MODES 3, 4 and 5 when the RTBs are closed provides assurance that, in the event of a rod withdrawal accident, there will be adequate flow in the core to avoid exceeding the DNBR limit. Bypass of the RCP variable speed control ensures that the pumps are operating at full flow. With the RTBs in the open position, the PLS is not capable of rod withdrawal; therefore only a minimum RCS flow of 3,000 gpm is necessary to ensure removal of decay heat from the core in accordance with LCO 3.4.8, Minimum RCS Flow. Note 1 prohibits startup of a RCP when the reactor trip breakers are closed. This requirement prevents startup of a RCP and the resulting circulation of cold and/or unborated water from an inactive loop into the core, precluding reactivity excursion events which are unanalyzed. Note 2 prohibits startup of an RCP when the RCS temperature is > 200350°F unless pressurizer level is < 92%. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started. Note 3 requires that the secondary side water temperature of each SG be ≤ 50°F above each of the RCS cold leg temperatures before the start of an RCP with any RCS cold leg temperature ≤ 200350°F-, and the RCP must be started at ≤ 25% of RCP speed. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started. This limitation also helps to ensure that the RNS system pressure remains below both the piping design pressure and the acceptable RNS relief valve inlet pressure. AP1000 B 3.4.4 - 3 Amendment 0 Revision 17

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### **Response to Request For Additional Information (RAI)**

Minimum RCS Flow B 3.4.8

#### BASES

LCO (continued)

NoteOTE 1 permits all RCPS to be de-energized for ≤ 1 hour per 8 hour period. The purpose of the NoteOTE is to permit tests that are designed to validate various accident analysis values. One of these tests is for the validation of the pump coastdown curve, used as input to a number of accident analyses including a loss of flow accident. This test is generally performed in MODE 3 during the initial startup testing program, and as such should only be performed once. If, however, changes are made to the RCS that would cause a change to the flow characteristics of the RCS, the input values of the coastdown curve may need to be revalidated by conducting the test again. Another test performed during the startup testing program is the validation of the rod drop times during cold conditions, both with and without flow. The no-flow tests may be performed in MODE 3, 4, or 5, and require that the pumps be stopped for a short period of time. The Note permits the de-energizing of the pumps in order to perform this test and validate the assumed analysis values. As with the validation of the pump coastdown curve, this test should only be performed once, unless the flow characteristics of the RCS are changed. The 1 hour time period specified is adequate to perform the desired tests and experience has shown that boron stratification is not a problem during this short period with no forced flow. Utilization of the NOTEote is permitted provided the following conditions are met along with any other conditions imposed by initial startup test procedures: No operations are permitted that would dilute the RCS boron a. concentration with coolant at boron concentrations less than required to assure the SDM of LCO 3.1.1, thereby maintaining the margin to criticality. Boron reduction with coolant at boron concentrations less than required to assure SDM is maintained is prohibited because a uniform concentration distribution throughout the RCS cannot be ensured when in natural circulation and Core outlet temperature is maintained at least 10°F below saturation b. temperature, so that no vapor bubble may form and possibly cause natural circulation flow obstruction. Note 2 prohibits startup of an RCP when the RCS temperature is ≥ 200350°F unless pressurizer level is < 92%. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started. B 3.4.8 - 2 Amendment 0 **Revision 17** 



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## **Response to Request For Additional Information (RAI)**

	Minimum RCS Flow B 3.4.8
BASES	
LCO (continued)	
• •	Note 3 requires that the secondary side water temperature of each SG be $\leq 50^{\circ}$ F above each of the RCS cold leg temperatures before the start of an RCP with any RCS cold leg temperature $\leq 20350^{\circ}$ F, and the RCP must be started at $\leq 25\%$ of RCP speed. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started. This limitation also helps to ensure that the RNS system pressure remains below both the piping design pressure and the acceptable RNS relief valve inlet pressure.
APPLICABILITY	Minimum RCS flow is required in MODES 3, 4, and 5 with the reactor trip breakers (RTBs) open and with unborated water sources not isolated from the RCS because an inadvertent BDE is considered possible in these MODES.
	In MODES 1 and 2, and in MODES 3, 4, and 5 with the RTBs closed, LCO 3.4.4 requires all four RCPs to be in operation. Thus, in the event of an inadvertent boron dilution, adequate mixing will occur.
	A minimum mixing flow is not required in MODE 6 because LCO 3.9.2 requires that all valves used to isolate unborated water sources shall be secured in the closed position. In this situation, an inadvertent BDE is not considered credible.
ACTIONS	<u>A.1</u>
	If no RCP is in operation, all sources of unborated water must be isolated within 1 hour. This action assures that no unborated water will be introduced into the RCS when proper mixing cannot be assured. The allowed Completion Time requires that prompt action be taken, and is based on the low probability of a DBA occurring during this time.
	<u>A.2</u>
	The Requirement to perform SR 3.1.1.1 (SDM verification) within 1 hour assures that if the boron concentration in the RCS has been reduced and not detected by the source range instrumentation, prompt action may be taken to restore the required SDM. The allowed Completion Time is consistent with that required of Action A.1 because the conditions and consequences are the same.
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### **Response to Request For Additional Information (RAI)**

LTOP System B 3.4.14

#### BASES

#### APPLICABLE SAFETY ANALYSES (continued)

The PTLR contains the acceptance limits that define the LTOP requirements. Any change to the RCS must be evaluated against the Reference 4 analyses to determine the impact of the change on the LTOP acceptance limits.

Transients that are capable of overpressurizing the RCS are categorized as either mass or heat input transients. The events listed below were used in the analysis to size the RNS suction relief valve. Therefore, any events with a mass or heat input greater than the listed events cannot be accommodated and must be prevented.

#### Mass Input

a. Makeup water flow rate to the RCS assuming both CVS makeup pumps are in operation and letdown is isolated.

#### Heat Input

 Restart of one reactor coolant pump (RCP) with water in the steam generator secondary side 50°F hotter than the primary side water, and the RCS water solid.

#### **RNS Suction Relief Valve Performance**

Since the RNS suction relief valve does not have a variable P/T lift setpoint, the analysis must show that with chosen setpoint, the relief valve will pass flow greater than that required for the limiting LTOP transient while maintaining RCS pressure less than the minimum of either the P/T limit curve, or 110 percent of the design pressure of the normal residual heat removal system, or the acceptable RNS relief valve inlet pressure. The current analysis shows that up to a temperature of 70°F, the mass input transient is limiting, and above this temperature the heat input transient is limiting.

To prevent the possibility of a heat input transient, and thereby limit the required flow rate of the RNS suction relief valve, an administrative requirements in the LCO note haves been imposed for starting an RCP, that does not allow an RCP to be started with the pressurizer water level above 92% and the RCS temperature above 200°F. Under these imposed conditions, the transient created by the startup of an RCP when the RCS temperature is above 200°F can be accommodated without additional pressure relief.

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## **Response to Request For Additional Information (RAI)**

BASES	
LCO (continued)	
	b. A depressurized RCS and an RCS vent.
2	An RCS vent is OPERABLE when open with an area of ≥ 4.15 square inches.
	Each of these methods of overpressure prevention is capable of mitigating the limiting LTOP transient.
	Note 1 prohibits startup of an RCP when the RCS temperature is $\geq$ 350°F unless pressurizer level is < 92%. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started
	Note 2 requires that the secondary side water temperature of each SG be $\leq$ 50°F above each of the RCS cold leg temperatures before the start of an RCP with any RCS cold leg temperature $\leq$ 350°F, and the RCP must be started at $\leq$ 25% of RCP speed. This restraint is to prevent a low temperature overpressure event due to a thermal transient when an RCP is started. This limitation also helps to ensure that the RNS system pressure remains below both the piping design pressure and the acceptable RNS relief valve inlet pressure.
APPLICABILITY	This LCO is applicable in MODE 4 when any cold leg temperature is below 275°F, MODE 5, and in MODE 6 when the reactor vessel head is on. The pressurizer safety valves provide overpressure protection that meets the Reference 1 P/T limits above 275°F. In MODE 6, the reactor vessel head is off, and overpressurization cannot occur.
	LCO 3.4.3 provides the operational P/T limits for all MODES. LCO 3.4.6, "Pressurizer Safety Valves," requires the OPERABILITY of the pressurizer safety valves that provide overpressure protection during MODES 1, 2, and 3, and MODE 4 with the RNS isolated or RCS temperature $\geq$ 275°F.
•	Low temperature overpressure prevention is most critical during shutdown when the RCS is water solid, and a mass or heat input transient can cause a very rapid increase in RCS pressure with little or no time for operator action to mitigate the event.
	The Applicability is modified by a Note stating that accumulator isolation is only required when the accumulator pressure is more than or at the maximum RCS pressure for the existing temperature, as allowed by the P/T limit curves.
	This Note permits the accumulator discharge isolation valve Surveillance to be performed only under these pressure and temperature conditions.
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