3.1 REACTIVITY CONTROL SYSTEMS

3.1.7 Standby Liquid Control (SLC) System

LCO 3.1.7 Two SLC subsystems shall be OPERABLE.

APPLICABILITY: MODES 1 and 2.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Concentration of boron in solution not within limits.	A.1 Restore concentration of boron in solution to within limits.	72 hours AND 10 days from discovery of failure to meet the LCO
B. One SLC subsystem inoperable for reasons other than Condition A.	B.1 Restore SLC subsystem to OPERABLE status.	7 days AND 10 days from discovery of failure to meet the LCO
C. Two SLC subsystems inoperable for reasons other than Condition A.	C.1 Restore one SLC subsystem to OPERABLE status.	8 hours
D. Required Action and associated Completion Time not met.	D.1 Be in MODE 3.	12 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.7.1	Verify available volume of sodium pentaborate solution is [≥ 23.1 m^3 (6103 gallons)].	24 hours
SR 3.1.7.2	Verify temperature of sodium pentaborate solution is within the limits of Figure 3.1.7-1.	24 hours
SR 3.1.7.3	Verify temperature of pump suction piping is within the limits of [Figure 3.1.7-1].	24 hours
SR 3.1.7.4	Verify the concentration of boron in solution is within the limits of Figure 3.1.7-1.	31 days AND Once within 24 hours after water or boron is added to solution AND Once within 24 hours after solution temperature is restored within the limits of Figure 3.1.7-1

ABWR SLC has no heat tracing on suction piping. The suction valve is located at the SLC tank. The pipe discharge piping is filled with demineralized water and also has no heat tracing.

(continued)

2

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.1.7.~~5~~ 4	Verify each SLC subsystem manual, power operated, and automatic valve in the flow path that is not locked, sealed, or otherwise secured in position is in the correct position, or can be aligned to the correct position.	31 days
SR 3.1.7.~~6~~ 5	Verify each pump develops a flow rate ≥ ~~[41.2] gpm~~ 11.4 m^3/h (50.0 gpm) at a discharge pressure ≥ ~~[1200] psig~~. 86 Kg/cm^2g (1223 psig)	~~In accordance with the Inservice Testing Program or~~ 92 days
SR 3.1.7.~~7~~ 6	Verify flow through one SLC subsystem from pump into reactor pressure vessel.	[18] months on a STAGGERED TEST BASIS
SR 3.1.7.~~8~~ 7	Verify that simultaneous operation of both pumps develop a flow rate ≥ 6.30 l/s (100 gpm) at a pressure of ~~67 units~~ 86.0 Kg/cm^2g (1223 psig).	[18] months
SR 3.1.7.9	Verify all heat traced piping between storage tank and pump suction is unblocked. See comment on SR 3.1.7.3.	[18] months AND Once within 24 hours after solution temperature is restored within the limits of [Figure 3.1.7-1]

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE	FREQUENCY
	(continued)
SR 3.1.7.10 Verify sodium pentaborate enrichment is ≥ [60.0] atom percent B-10. (?)	Prior to addition to SLC tank

Reactivity Control Systems
Standby Liquid Control (SLC) System
BASES

BACKGROUND

The SLC System is designed to provide the capability of bringing the reactor, at any time in a fuel cycle, from full power and minimum control rod inventory (which is at the peak of the xenon transient) to a subcritical condition with the reactor in the most reactive xenon free state without taking credit for control rod movement. The SLC System satisfies the requirements of 10 CFR 50.62 (Reference B3.1.7-1) on anticipated transient without scram (ATWS).

The SLC system consists of a boron solution storage tank, two positive displacement pumps, two motor operated injection valves, which are provided in parallel for redundancy, and associated piping and valves used to transfer borated water from the storage tank to the reactor pressure vessel (RPV). The borated solution is discharged through the "B" High Pressure Core Flooder (HPCF) subsystem ~~—~~ Sparger

APPLICABLE SAFETY ANALYSES

The SLC System is automatically initiated. The SLC System is used in the event that not enough control rods can be inserted to accomplish shutdown and cooldown in the normal manner. The SLC System injects borated water into the reactor core to compensate for all of the various reactivity effects that could occur during plant operation. To meet this objective, it is necessary to inject a quantity of boron that produces a concentration of 850 ppm of natural boron in the reactor core at 21°C (70°F). To allow for potential leakage and imperfect mixing in the reactor system, an additional amount of boron equal to 25% of the amount cited above is added (Reference B3.1.7-2). The temperature versus concentration limits in Figure 3.1.7-1 (in the accompanying LCO) are calculated such that the required concentration is achieved accounting for dilution in the RPV with normal water level and including the water volume in the residual heat removal shutdown cooling piping. This quantity of borated solution is the amount that is above the pump suction shutoff level in the boron solution storage tank. No credit is taken for the portion

of the tank volume that cannot be injected.

The SLC System satisfies the requirements of the NRC Policy Statement because operating experience and probabilistic risk assessment have generally shown it to be important to public health and safety.

LCO

The OPERABILITY of the SLC System provides backup capability for reactivity control, independent of normal reactivity control provisions provided by the control rods. The OPERABILITY of the SLC System is based on the conditions of the borated solution in the storage tank and the availability of a flow path to the RPV, including the OPERABILITY of the pumps and valves. Because the minimum required boron solution concentration is the same for both ATWS mitigation and cold shutdown (unlike some previous reactor designs) then if the boron solution concentration is less than the required limit, both SLC subsystems shall be declared inoperable. Two SLC subsystems are required to be OPERABLE, each containing an OPERABLE pump, a motor operated injection valve, and associated piping, valves, and instruments and controls to ensure an OPERABLE flow path.

APPLICABILITY

In MODES 1 and 2, shutdown capability is required. In MODES 3 and 4, control rods are only allowed to be withdrawn under Special Operations LCO 3.10.3, "Control Rod Withdrawal—Hot Shutdown," and LCO 3.10.4, "Control Rod Withdrawal—Cold Shutdown," which provide adequate controls to ensure the reactor remains subcritical. In MODE 5, only a single control rod or control rod pair can be withdrawn from a core cell containing fuel assemblies. Demonstration of adequate SDM (LCO 3.1.1, "SHUTDOWN MARGIN (SDM)") ensures that the reactor will not become critical. Therefore, the SLC System is not required to be OPERABLE during these conditions, when only a single control rod or control rod pair can be withdrawn.

INSERT A.1

ACTIONS B A.1

If one SLC System subsystem is inoperable, the inoperable subsystem must be restored to OPERABLE status within 7 days. In this condition, the remaining OPERABLE subsystem is adequate to perform the shutdown function. However, the overall reliability is reduced because a single failure in the remaining OPERABLE subsystem could

A.1

If the boron concentration is less than the required limits given in Figure 3.1.7-1 the concentration must be restored to within limits in 72 hours. For ATWS prevention/mitigation the ABWR features; an automatic rod insert (ARI) and an electrical insertion of FMCRDs both of which utilize sensors and logic that are diverse and independent of the reactor protection system; an ATWS recirculation pump trip (RPT); and, automatic initiation of SLCS under ATWS conditions (Ref. B3.1.7-3). These features provide the ABWR an ATWS prevention and mitigation capability well beyond previous BWRs. Because of the low probability of an ATWS event, the ATWS prevention/mitigation features and that the SLC System capability still exists for vessel injection under these conditions, the allowed Completion Time of 72 hours is acceptable and provides adequate time to restore concentration to within limits. The maximum Completion Time of 10 days is allowed for this LCO in the event of multiple Condition Entry.

result in reduced SLC System shutdown capability. The 7 day Completion Time is based on the availability of an OPERABLE subsystem capable of performing the intended SLC System function and the low probability of a Design Basis Accident (DBA) or severe transient occurring concurrent with the failure of the Control Rod Drive System to shut down the plant. The maximum Completion Time of 10 days is allowed for this LCO in the event of multiple Condition entry.

C ~~B~~.1 →

If both SLC subsystems are inoperable, at least one subsystem must be restored to OPERABLE status within 8 hours. The allowed Completion Time of 8 hours is considered acceptable, given the low probability of a DBA or transient occurring concurrent with the failure of the control rods to shut down the reactor.

D ~~E~~.1 →

If any Required Action and associated Completion Time is not met, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to MODE 3 within 12 hours. The allowed Completion Time of 12 hours is reasonable, based on operating experience, to reach MODE 3 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.1.7.1 and ~~SR 3.1.7.2, and SR 3.1.7.3~~ →

SR 3.1.7.1 ~~through~~ and SR 3.1.7.2 are 24 hour Surveillances, verifying certain characteristics of the SLC System (e.g., the volume and temperature of the borated solution in the storage tank), thereby ensuring the SLC System OPERABILITY without disturbing normal plant operation. These Surveillances ensure the proper borated solution and temperature~~, including the temperature of the pump suction piping,~~ are maintained. Maintaining a minimum specified borated solution temperature is important in ensuring that the boron remains in solution and does not precipitate out in the storage tank~~, or in the pump suction piping.~~ The 24 hour Frequency of these SRs is

based on operating experience that has shown there are relatively slow variations in the measured parameters of volume and temperature.

SR 3.1.7.~~5~~ 3 →

This Surveillance requires an examination of the sodium pentaborate solution by using chemical analysis to ensure the proper concentration of boron exists in the storage tank. SR 3.1.7.~~4~~ 3 must be performed anytime boron or water is added to the storage tank solution to establish that the boron solution concentration is within the specified limits. This Surveillance must be performed anytime the temperature is restored to within the limits of Figure 3.1.7-1, to ensure no significant boron precipitation occurred. The 31 day Frequency of this Surveillance is appropriate because of the relatively slow variation of boron concentration between surveillances.

SR 3.1.7.~~6~~ 4 →

SR 3.1.7.~~5~~ 4 verifies each valve in the system is in its correct position. Verifying the correct alignment for manual, power operated, and automatic valves in the SLC System flow path ensures that the proper flow paths will exist for system operation. This Surveillance does not apply to valves that are locked, sealed, or otherwise secured in position, since they were verified to be in the correct position prior to locking, sealing, or securing. This verification of valve alignment does not apply to valves that cannot be inadvertently misaligned, such as check valves. This SR does not require any testing or valve manipulation; rather, it involves verification that those valves capable of being mispositioned are in the correct positions. The 31 day Frequency is based on engineering judgment and is consistent with the procedural controls governing valve operation that ensure correct valve positions.

SR 3.1.7.~~4~~ 5 →

Demonstrating each SLC System pump develops a flow rate ≥ 11.4 m

3

/h (50 gpm) at a discharge pressure ≥ 86.0 Kg/cm

g (1223 psig) ensures that pump performance has not degraded during the fuel cycle. This minimum pump flow rate requirement ensures that, when combined with the sodium pentaborate solution concentration requirements, the rate of negative reactivity insertion from the SLC System will adequately compensate for the positive reactivity effects encountered during power reduction, cooldown of the moderator, and xenon decay. This test confirms one point on the pump design curve, and is indicative of overall performance. Such inservice inspections confirm component OPERABILITY, trend performance, and detect incipient failures by indicating abnormal performance. The Frequency of this Surveillance is ~~in accordance with the Inservice Testing Program or~~ 92 days.

SR 3.1.7.~~1~~ 6 and SR 3.1.7.~~2~~ 7 →

These Surveillances ensure that there is a functioning flow path from the boron solution storage tank to the RPV. The pump and injection valve tested should be alternated such that both complete flow paths are tested every 36 months, at alternating 18 month intervals. The Surveillance may be performed in separate steps to prevent injecting boron into the RPV. An acceptable method for verifying flow from the pump to the RPV is to pump demineralized water from a test tank through one SLC subsystem and into the RPV. The 18 month Frequency ~~is~~ ies are based on the need to perform this ~~Surveillance~~ ose s under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance(s) were performed with the reactor at power. Operating experience has shown these components usually pass the Surveillance test when performed at the 18 month Frequency; therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

~~Demonstrating that all heat traced piping between the boron solution storage tank and the suction inlet to the injection pumps is unblocked ensures that there is a functioning flow path for injecting the sodium pentaborate solution. An acceptable method for verifying~~

In SR 3.1.7.6 →

In SR 3.1.7.7, both SLCS pumps are tested for simultaneous operation.

that the suction piping is unblocked is to pump from the storage tank to the test tank. The 18 month Frequency is acceptable since there is a low probability that the subject piping will be blocked due to precipitation of the boron from solution in the heat traced piping. This is especially true in light of the daily temperature verification of this piping required by SR 3.1.7.3. However, if, in performing SR 3.1.7.8, it is determined that the temperature of this piping has fallen below the specified minimum, this Surveillance must be performed once within 24 hours after the piping temperature is restored within the limits of Figure 3.1.7-1.

REFERENCES

B3.1.7-L. 10 CFR 50.62.

" 2. ABWR SSAR, Section 9.3.5.3.

" 3. AOWA SSAR, Section 15.8.2.