

B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.1 Accumulators

BASES

BACKGROUND The functions of the ECCS accumulators are to supply water to the reactor vessel during the blowdown phase of a loss of coolant accident (LOCA), to provide inventory to help accomplish the refill phase that follows thereafter, and to provide Reactor Coolant System (RCS) makeup for a small break LOCA.

The blowdown phase of a large break LOCA is the initial period of the transient during which the RCS departs from equilibrium conditions, and heat from fission product decay, hot internals, and the vessel continues to be transferred to the reactor coolant. The blowdown phase of the transient ends when flow from the accumulators or safety injection (SI) begins (Ref. 1).

In the refill phase of a LOCA, which immediately follows the blowdown phase, reactor coolant inventory has vacated the core through steam flashing and ejection out through the break. The core is essentially in adiabatic heatup. The balance of accumulator inventory is then available to help fill voids in the lower plenum and reactor vessel downcomer so as to establish a recovery level at the bottom of the core and ongoing reflood of the core with the addition of SI water.

The accumulators are pressure vessels partially filled with borated water and pressurized with nitrogen gas. Boric acid used in the accumulators is enriched in B-10 to allow for a reduction in the boric acid concentration. The accumulators are passive components, since no operator or control actions are required in order for them to perform their function. Internal accumulator tank pressure is sufficient to discharge the accumulator contents to the RCS, if RCS pressure decreases below the accumulator pressure.

Each accumulator is piped into an RCS cold leg via an accumulator line and is isolated from the RCS by a motor-operated isolation valve and two check valves in series.

The accumulator size, water volume, and nitrogen cover pressure are selected so that three of the four accumulators are sufficient to partially cover the core before significant clad melting or zirconium water reaction can occur following a LOCA. The need to ensure that three accumulators are adequate for this function is consistent with the LOCA assumption that the entire contents of one accumulator will be lost via the RCS pipe break during the blowdown phase of the LOCA.

BASES

APPLICABLE SAFETY ANALYSES

The accumulators are assumed OPERABLE in both the large and small break LOCA analyses at full power (Ref. 1). These are the Design Basis Accidents (DBAs) that establish the acceptance limits for the accumulators. Reference to the analyses for these DBAs is used to assess changes in the accumulators as they relate to the acceptance limits.

In performing the LOCA calculations, conservative assumptions are made concerning the availability of ECCS flow. In the early stages of a LOCA, with or without a loss of offsite power, the accumulators provide the sole source of makeup water to the RCS. The assumption of loss of offsite power is required by regulations and conservatively imposes a delay wherein the ECCS pumps cannot deliver flow until the emergency diesel generators start, come to rated speed, and go through their timed loading sequence. In cold leg break scenarios, the entire contents of one accumulator are assumed to be lost through the break.

The limiting large break LOCA is a double ended guillotine break in the cold leg piping between the reactor coolant pump and the reactor vessel for the RCS loop containing the pressurizer. During this event, the accumulators discharge to the RCS as soon as RCS pressure decreases to below accumulator pressure.

As a conservative estimate, no credit is taken for ECCS pump flow until an effective delay has elapsed. This delay accounts for the diesels starting and the pumps being loaded and delivering full flow. During this time, the accumulators are analyzed as providing the sole source of emergency core cooling. No operator action is assumed during the blowdown stage of a large break LOCA.

The worst case small break LOCA analyses also assume a time delay before pumped flow reaches the core. The Protection System automatically starts the Medium Head Safety Injection (MHSI) and Low Head Safety Injection (LHSI) pumps and initiates a partial cooldown of the secondary system. The degree of accumulator discharge into the RCS depends on RCS pressure.

This LCO helps to ensure that the following acceptance criteria established for the ECCS by 10 CFR 50.46 (Ref. 2) will be met following a LOCA:

- a. Maximum fuel element cladding temperature is $\leq 2200^{\circ}\text{F}$;
- b. Maximum cladding oxidation is ≤ 0.17 times the total cladding thickness before oxidation;

BASES

APPLICABLE SAFETY ANALYSES (continued)

- c. Maximum hydrogen generation from a zirconium water reaction is ≤ 0.01 times the hypothetical amount that would be generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react; and
- d. Core is maintained in a coolable geometry.

Since the accumulators discharge during the blowdown phase of a LOCA, they do not contribute to the long term cooling requirements of 10 CFR 50.46.

For both the large and small break LOCA analyses, a nominal contained accumulator water volume is used. The contained water volume is the same as the deliverable volume for the accumulators, since the accumulators are emptied, once discharged. For small breaks, an increase in water volume is a peak clad temperature penalty. For large breaks, an increase in water volume can be either a peak clad temperature penalty or benefit, depending on downcomer filling and subsequent spill through the break during the core reflooding portion of the transient. The analysis makes a conservative assumption with respect to ignoring or taking credit for line water volume from the accumulator to the check valve. The safety analysis assumes values of 1236 ft³ and 1412.6 ft³.

The minimum boron concentration setpoint is used in the post LOCA boron concentration calculation. The calculation is performed to assure reactor subcriticality in a post LOCA environment. Of particular interest is the large break LOCA, since no credit is taken for control rod assembly insertion. A reduction in the accumulator minimum boron concentration would produce a subsequent reduction in the available containment sump concentration for post LOCA shutdown and an increase in the maximum sump pH. The maximum boron concentration is used in determining the cold leg to hot leg recirculation injection switchover time and minimum sump pH.

The large and small break LOCA analyses are performed at the minimum nitrogen cover pressure, since sensitivity analyses have demonstrated that higher nitrogen cover pressure results in a computed peak clad temperature benefit. The maximum nitrogen cover pressure limit prevents accumulator relief valve actuation, and ultimately preserves accumulator integrity.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The effects on containment mass and energy releases from the accumulators are accounted for in the appropriate analyses (Refs. 1 and 3).

The accumulators satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

The LCO establishes the minimum conditions required to ensure that the accumulators are available to accomplish their core cooling safety function following a LOCA. Four accumulators are required to ensure that 100% of the contents of three of the accumulators will reach the core during a LOCA. This is consistent with the assumption that the contents of one accumulator spill through the break. If less than three accumulators are injected during the blowdown phase of a LOCA, the ECCS acceptance criteria of 10 CFR 50.46 (Ref. 2) could be violated.

For an accumulator to be considered OPERABLE, the isolation valve must be fully open, power removed above 2000 psig, and the limits established in the SRs for contained volume, boron concentration, boron isotopic inventory, and nitrogen cover pressure must be met.

APPLICABILITY

In MODES 1 and 2, and in MODE 3 with RCS pressure > 1000 psig, the accumulator OPERABILITY requirements are based on full power operation. Although cooling requirements decrease as power decreases, the accumulators are still required to provide core cooling as long as elevated RCS pressures and temperatures exist.

This LCO is only applicable at pressures > 1000 psig. At pressures ≤ 1000 psig, the rate of RCS blowdown is such that the ECCS pumps can provide adequate injection to ensure that peak clad temperature remains below the 10 CFR 50.46 (Ref. 2) limit of 2200°F.

In MODE 3, with RCS pressure ≤ 1000 psig, and in MODES 4, 5, and 6, the accumulator motor-operated isolation valves are closed to isolate the accumulators from the RCS. During RCS heatup and cooldown, one accumulator is pressurized to approximately 304 psig and connected to the RCS to prevent Reactor Coolant Pump (RCP) seal damage in the event of an inadvertent RCS depressurization when the pressurizer is in a water solid state. For heatup, the accumulator is isolated once the pressurizer level is established at the LCO limit. On cooldown, once all RCPs are stopped, the accumulator is again isolated.

BASES

ACTIONS

A.1

If the boron concentration or boron enrichment of one accumulator is not within limits, it must be returned to within the limits within 72 hours. In this Condition, ability to maintain subcriticality or minimum boron precipitation time may be reduced. The boron in the accumulators contributes to the assumption that the combined ECCS water in the partially recovered core during the early reflooding phase of a large break LOCA is sufficient to keep that portion of the core subcritical. One accumulator below the minimum boron concentration or enrichment limit, however, will have no effect on available ECCS water and an insignificant effect on core subcriticality during reflood. Boiling of ECCS water in the core during reflood concentrates boron in the saturated liquid that remains in the core. In addition, the main steam line break analysis demonstrates that the accumulators do not discharge following a large main steam line break. Even if they do discharge, their impact is minor and not a design limiting event. Thus, 72 hours is allowed to return the boron concentration and enrichment to within limits.

B.1

If one accumulator is inoperable for a reason other than boron concentration or enrichment, the accumulator must be returned to OPERABLE status within 1 hour. In this Condition, the required contents of three accumulators cannot be assumed to reach the core during a LOCA. Due to the severity of the consequences should a LOCA occur in these conditions, the 1 hour Completion Time to open the valve, remove power to the valve, or restore the proper water volume or nitrogen cover pressure ensures that prompt action will be taken to return the inoperable accumulator to OPERABLE status. The Completion Time minimizes the potential for exposure of the plant to a LOCA under these conditions.

C.1 and C.2

If the accumulator cannot be returned to OPERABLE status within the associated Completion Time, 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 6 hours and RCS pressure reduced to ≤ 1000 psig within 12 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

BASES

ACTIONS (continued)

D.1

If more than one accumulator is inoperable, the plant is in a condition outside the accident analyses; therefore, LCO 3.0.3 must be entered immediately.

SURVEILLANCE REQUIREMENTS

SR 3.5.1.1

Each accumulator valve should be verified to be fully open every 12 hours. This verification ensures that the accumulators are available for injection and ensures timely discovery if a valve should be less than fully open. If an isolation valve is not fully open, the rate of injection to the RCS would be reduced. Although a motor-operated valve position should not change with power removed, a closed valve could result in not meeting accident analyses assumptions. The 12 hour Frequency is considered reasonable in view of other administrative controls that ensure a mispositioned isolation valve is unlikely.

SR 3.5.1.2 and SR 3.5.1.3

Every 12 hours, borated water volume and nitrogen cover pressure are verified for each accumulator. This Frequency is sufficient to ensure adequate injection during a LOCA. Because of the static design of the accumulator, a 12 hour Frequency usually allows the operator to identify changes before limits are reached. Operating experience has shown this Frequency to be appropriate for early detection and correction of off normal trends.

SR 3.5.1.4

The boron concentration should be verified to be within required limits for each accumulator every 31 days since the static design of the accumulators limits the ways in which the concentration can be changed. The 31 day Frequency is adequate to identify changes that could occur from mechanisms such as stratification or inleakage. Sampling the affected accumulator within 6 hours after a 145 gallon (1%) volume increase will identify whether inleakage has caused a reduction in boron

BASES

SURVEILLANCE REQUIREMENTS (continued)

concentration to below the required limit. It is not necessary to verify boron concentration if the added water inventory is from the In-Containment Refueling Water Storage Tank (IRWST), because the water contained in the IRWST is within the accumulator boron concentration requirements. This is consistent with the recommendation of NUREG-1366 (Ref. 4).

SR 3.5.1.5

Verification every 31 days that power is removed from each accumulator isolation valve operator when the RCS pressure is ≥ 2000 psig ensures that an active failure could not result in the undetected closure of an accumulator motor-operated isolation valve. If this were to occur, only two accumulators would be available for injection given a single failure coincident with a LOCA. Since power is removed under administrative control, the 31 day Frequency will provide adequate assurance that power is removed.

The SR is modified by a Note that requires electrical power supplied to the motor-operated isolation valves to be verified de-energized when RCS pressure is > 2000 psig. This allows operational flexibility by avoiding unnecessary delays to manipulate the breakers during plant startups or shutdowns.

SR 3.5.1.6

The boron used in the accumulators is enriched to $\geq 37\%$ in the B-10 isotope. Verification every 24 months that the B-10 enrichment is $\geq 37\%$ ensures that the B-10 concentration assumed in the accident analysis is available. Since B-10 in the accumulators is not exposed to a significant neutron field, the 24 month Frequency is considered conservative.

REFERENCES

1. FSAR Section 15.6.
 2. 10 CFR 50.46.
 3. FSAR Section 6.2.
 4. NUREG-1366, February 1990.
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B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.2 ECCS - Operating

BASES

BACKGROUND

The function of the ECCS is to provide core cooling and negative reactivity to ensure that the reactor core is protected after any of the following accidents:

- a. Loss of coolant accident (LOCA), coolant leakage greater than the capability of the normal charging system;
- b. Rod ejection accident;
- c. Loss of secondary coolant accident, including uncontrolled steam release or loss of feedwater; and
- d. Steam generator tube rupture (SGTR).

The addition of negative reactivity is designed primarily for the loss of secondary coolant accident where primary cooldown could add enough positive reactivity to achieve criticality and return to significant power.

There are two phases of ECCS operation: injection and hot leg recirculation. In the injection phase, water is taken from the In-Containment Refueling Water Storage Tank (IRWST) and injected into the Reactor Coolant System (RCS) through the cold legs. After approximately one hour, a portion of the LHSI flow is shifted to hot leg injection to backflush the loops, reduce the boiling in the top of the core, and recapture any boron precipitation.

Each ECCS train consists of two separate subsystems: Medium Head Safety Injection (MHSI) and Low Head Safety Injection (LHSI). Each ECCS flow path consists of piping, valves, one LHSI heat exchanger, and pumps that provide a means to transfer the water from IRWST to one RCS loop cold leg. Four separate suction supply lines supply water from the IRWST to the ECCS pumps. Each ECCS train is capable of providing 100 percent of the required flow to mitigate the design basis accident (DBA). With the ECCS cross-connects closed, each of the four trains is independent and injects into a single RCS cold leg.

BASES

BACKGROUND (continued)

If it is necessary to remove one LHSI train from service, an isolatable ECCS cross-connect ensures LHSI delivery in the event of a cold leg break. Whenever the cross-connects are opened, the isolation valve electrical breakers are racked-out to avoid single failure. Otherwise, both ECCS cross-connects are isolated to maintain LHSI train separation.

The ECCS accumulators and the IRWST are also part of the ECCS, but are not considered part of an ECCS flow path as described by this LCO.

Cross-connect capability is provided between Trains 1 and 2 and between Trains 3 and 4 for the LHSI pumps. Cross-connect capability allows one LHSI train to be removed from service for maintenance and provides alternate injection paths for the LHSI trains that remain in service. This configuration mitigates the effect of potential degraded injection flow due to steam entrainment during a loss of coolant event. At higher pressures when the MHSI pumps provide the injection flow, steam entrainment is not a concern; therefore no cross-connects are required between the MHSI trains.

Each ECCS flow path consists of piping, valves, heat exchangers, and pumps such that water from the IRWST can be injected into the RCS following the accidents described in this LCO. The major components of each subsystem are the MHSI pumps, the LHSI pumps, and LHSI heat exchangers. Each of the two subsystems (MHSI and LHSI) consists of four 100% capacity trains that are independent and redundant such that each train is capable of supplying 100% of the flow required to mitigate the accident consequences.

For LOCAs that are too small to depressurize the RCS below the shutoff head of the MHSI pumps, the secondary side is cooled down to approximately 870 psia at a rate of approximately 180°F/hr by means of the relief valves to ensure adequate injection from the MHSI System.

BASES

BACKGROUND (continued)

Due to the large miniflow lines, it is not necessary to limit the number of MHSI or LHSI pumps in service during low temperature conditions in the RCS. Refer to the Bases for LCO 3.4.11, "Low Temperature Overpressure Protection (LTOP) System," for the basis of low RCS temperature operation.

The ECCS subsystems are actuated upon receipt of a Protection System (PS) signal. The actuation of safeguard loads is accomplished in a programmed time sequence. If offsite power is available, the safeguard loads start in the programmed sequence. If offsite power is not available, the Engineered Safety Feature (ESF) buses shed normal operating loads and are connected to the emergency diesel generators (EDGs). Safeguard loads are then actuated in the programmed time sequence. The time delay associated with diesel starting, sequenced loading, and pump starting determines the time required before pumped flow is available to the core following a LOCA.

The active ECCS components, along with the passive accumulators and the IRWST covered in LCO 3.5.1, "Accumulators," and LCO 3.5.4, "In-Containment Refueling Water Storage Tank (IRWST) - Operating," provide the cooling water necessary to meet GDC 35 (Ref. 1).

APPLICABLE SAFETY ANALYSES

The LCO helps to ensure that the following acceptance criteria for the ECCS, established by 10 CFR 50.46 (Ref. 2), will be met following a LOCA:

- a. Maximum fuel element cladding temperature is $\leq 2200^{\circ}\text{F}$;
- b. Maximum cladding oxidation is ≤ 0.17 times the total cladding thickness before oxidation;
- c. Maximum hydrogen generation from a zirconium water reaction is ≤ 0.01 times the hypothetical amount generated if all of the metal in the cladding cylinders surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react;
- d. Core is maintained in a coolable geometry; and
- e. Adequate long term core cooling capability is maintained.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The LCO also limits the post trip return to power following an MSLB event and ensures that containment temperature limits are met.

Each ECCS subsystem is taken credit for in a large break LOCA event at full power (Refs. 3 and 4). This event establishes the requirement for runout flow for the ECCS pumps, as well as the maximum response time for their actuation. The MHSI and LHSI pumps are credited in a small break LOCA event. This event establishes the flow and discharge head at the design point for the MHSI pumps. The SGTR and MSLB events also credit the MHSI pumps. The OPERABILITY requirements for the ECCS are based on the following LOCA analysis assumptions:

- a. A large break LOCA event, with loss of offsite power; and
- b. A small break LOCA event, with a loss of offsite power.

ECCS cross-connects are provided for the LHSI trains to allow the removal of one train from service. Cross-connects are normally isolated by two motor-operated valves (MOV) arranged in a series configuration. The MOVs provide separation of LHSI trains when the valves are closed. The cross-connects provide the ability to cross-tie between Trains 1 and 2 or between Trains 3 and 4. The cross-connects do not provide the ability to cross-tie between any other train combinations. When the cross-connects are opened and the associated LHSI trains are cross-tied, the electrical power is required to be removed from the MOVs to ensure the valves remain in the required position.

If LHSI Train 1 is removed from service, the MOVs between Train 1 and 2 are opened, and additionally the MOVs between Trains 3 and 4 are also opened. With this configuration, if a DBA were to occur Train 2 would provide 50 percent of the required design flow to RCS loop 1, and 50 percent to RCS loop 2. For Train 3 and Train 4, 100 percent of the required design flow would be provided to RCS loops 3 and 4. The most limiting event is an RCP cold leg break. If Train 2 was lost because of a single failure, and Train 4 assumed to have the break, flow would be lost and Train 3 would provide sufficient flow to the core.

BASES

APPLICABLE SAFETY ANALYSES (continued)

During the blowdown stage of a LOCA, the RCS depressurizes as primary coolant is ejected through the break into the containment. The nuclear reaction is terminated either by moderator voiding during large breaks or control rod insertion for small breaks. Following depressurization, emergency cooling water is injected into the cold legs, flows into the downcomer, fills the lower plenum, and refloods the core.

The effects on containment mass and energy releases are accounted for in appropriate analyses (Refs. 3 and 4). The LCO ensures that an ECCS train will deliver sufficient water to match boil off rates soon enough to minimize the consequences of the core being uncovered following a large LOCA. It also ensures that the MHSI pumps will deliver sufficient water and boron during a small LOCA to maintain core subcriticality. For smaller LOCAs, the MHSI pump delivers sufficient fluid to maintain RCS inventory. For a small break LOCA, the steam generators continue to serve as the heat sink, providing part of the required core cooling. The cooling capability of the steam generators is enhanced by the operation of the secondary side main steam relief trains.

The ECCS trains satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

In Modes 1, 2 and 3, four 100% capacity independent (cross-connect closed) ECCS trains are required to ensure that sufficient ECCS flow is available. One of the four ECCS trains is assumed unavailable due to maintenance. Additionally, individual components within the ECCS trains may be called upon to mitigate the consequences of other transients and accidents.

An ECCS train consists of an MHSI train, and an LHSI train. Each ECCS train includes the piping, instruments, and controls to ensure an OPERABLE flow path capable of injecting upon an PS signal.

During an event requiring ECCS actuation, a flow path is required to provide an abundant supply of water from the IRWST to the RCS via the ECCS pumps to the individual cold leg injection nozzles. In the long term, the LHSI flow path may be switched to supply its flow to the RCS hot and cold legs.

The IRWST is sized to ensure that an adequate volume of borated water is available in the event of a DBA. The IRWST is addressed in LCO 3.5.4.

BASES

APPLICABILITY

In MODES 1, 2, and 3, the ECCS OPERABILITY requirements for the limiting Design Basis Accident, a large break LOCA, are based on full power operation. Although reduced power would not require the same level of performance, the accident analysis does not provide for reduced cooling requirements in the lower MODES. The MHSI pump performance requirements are based on a small break LOCA. MODE 2 and 3 requirements are bounded by the MODE 1 analysis.

This LCO is only applicable in MODE 3 and above. Below 350°F, the PS signal setpoint for the LHSI System is manually bypassed by operator control (in order to allow the alignment of the LHSI System in RHR mode), and system functional requirements are relaxed as described in LCO 3.5.3, "ECCS - Shutdown, MODE 4."

In MODES 5 and 6, plant conditions are such that the probability of an event requiring ECCS injection is extremely low. Core cooling requirements in MODE 5 are addressed by LCO 3.4.7, "RCS Loops - MODE 5, Loops Filled," and LCO 3.4.8, "RCS Loops - MODE 5, Loops Not Filled." MODE 6 core cooling requirements are addressed by LCO 3.9.4, "RHR Loops - High Water Level," and LCO 3.9.5, "RHR Loops - Low Water Level."

ACTIONS

A.1, B.1 and B.2

With one MHSI train inoperable, the inoperable components must be returned to OPERABLE status within 120 days. The 120 day Completion Time is based on the assumption in the FSAR Chapter 15 analysis that one ECCS train is assumed out of service for maintenance at the time of the accident.

With one LHSI train inoperable, an acceptable ECCS configuration can be achieved by opening both ECCS cross connections. In the event of a cold leg break, one train is assumed lost due to steam entrainment to the broken loop, one train is assumed to mitigate the event, and one train is assumed to have a single failure.

An ECCS train is inoperable if it is not capable of delivering design flow to the RCS. Individual components are inoperable if they are not capable of performing their design function or supporting systems are not available.

BASES

ACTIONS (continued)

The LCO requires the OPERABILITY of a number of independent subsystems. Due to the redundancy of trains and the diversity of subsystems, the inoperability of one component in a train does not render the ECCS incapable of performing its function. Neither does the inoperability of two different components, each in a different train, necessarily result in a loss of function for the ECCS. This allows increased flexibility in plant operations under circumstances when components in opposite trains are inoperable.

An event accompanied by a loss of offsite power and the failure of an EDG can disable one ECCS train until power is restored.

C.1

With two ECCS trains inoperable, at least one train must be restored to OPERABLE status in 72 hours. A reliability analysis (Ref. 5) has shown that the impact of having only one full ECCS train OPERABLE is sufficiently small to justify continued operation for 72 hours. This allowed Completion Time is reasonable since two trains are available and only one train is required to accomplish the safety function. Even with the most adverse configuration of two ECCS trains in the same pair (i.e., Trains 1 and 2 or Trains 3 and 4) inoperable and a cold leg break between the RCP and the vessel with the ECCS cross connects open, adequate flow is delivered to the core. With only two trains OPERABLE, the single failure criterion is not met.

D.1 and D.2

If the inoperable train(s) cannot be returned to OPERABLE status within the associated Completion Time, 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 6 hours and MODE 4 within 12 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

E.1

Condition E is applicable with three or more trains inoperable. With less than 100% of the ECCS flow equivalent to two OPERABLE ECCS trains available, the facility is in a condition outside of the accident analyses. Therefore, LCO 3.0.3 must be entered immediately.

BASES

SURVEILLANCE
REQUIREMENTS

SR 3.5.2.1

Verifying the correct alignment for manual, power operated and automatic valves in the ECCS flow paths provides assurance that the proper flow paths will exist for ECCS operation. The ECCS flow path verification includes the LHSI pump cold leg cross-connect valves are in their required position. This SR does not apply to valves that are locked, sealed, or otherwise secured in position, since these were verified to be in the correct position prior to locking, sealing, or securing. A valve that receives an actuation signal is allowed to be in a nonaccident position provided the valve will automatically reposition within the proper stroke time. This Surveillance does not require any testing or valve manipulation. Rather, it involves verification that those valves capable of being mispositioned are in the correct position. The 31 day Frequency is appropriate because the valves are operated under administrative control, and an improper valve position would only affect a single train. This Frequency has been shown to be acceptable through operating experience.

SR 3.5.2.2

The ECCS pumps are normally in a standby, nonoperating mode. As such, flow path piping has the potential to develop voids and pockets of entrained gases. Maintaining the piping from the ECCS pumps to the RCS full of water ensures that the system will perform properly, injecting its full capacity into the RCS upon demand. This will also prevent water hammer, pump cavitation, and pumping of noncondensable gas (e.g., air, nitrogen, or hydrogen) into the reactor vessel following a PS signal or during shutdown cooling. The 31 day Frequency takes into consideration the gradual nature of gas accumulation in the ECCS piping and the procedural controls governing system operation.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.2.3

Periodic surveillance testing of ECCS pumps to detect gross degradation caused by impeller structural damage or other hydraulic component problems is required by the ASME OM Code (Ref. 6). This type of testing may be accomplished by measuring the pump developed head at only one point of the pump characteristic curve. This verifies both that the measured performance is within an acceptable tolerance of the original pump baseline performance and that the performance at the test flow is greater than or equal to the performance assumed in the plant safety analysis. SRs are specified in the Inservice Testing Program of the ASME OM Code. The ASME OM Code provides the activities and Frequencies necessary to satisfy the requirements.

SR 3.5.2.4 and SR 3.5.2.5

These Surveillances demonstrate that each automatic ECCS valve actuates to the required position on an actual or simulated PS signal and that each ECCS pump starts on receipt of an actual or simulated PS signal. This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the required position under administrative controls. The 24 month Frequency is based on the need to perform these Surveillances under the conditions that apply during a plant outage and the potential for unplanned plant transients if the Surveillances were performed with the reactor at power. The 24 month Frequency is also acceptable based on consideration of the design reliability (and confirming operating experience) of the equipment. The actuation logic is tested as part of PS testing, and equipment performance is monitored as part of the Inservice Testing Program.

SR 3.5.2.6

Periodic inspections of the suction inlet from the IRWST ensure that it is unrestricted and stays in proper operating condition. The 24 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage, on the need to have access to the location, and because of the potential for an unplanned transient if the Surveillance were performed with the reactor at power. This Frequency has been found to be sufficient to detect abnormal degradation and is confirmed by operating experience.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.2.7

This Surveillance verifies that the LHSI flow split between the hot leg and the cold leg when in the hot leg injection mode remains consistent with analysis assumptions. The 24 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage.

SR 3.5.2.8

Verifying the containment heat removal capability provides assurance that the containment heat removal systems are capable of maintaining containment temperature below design limits following an accident. This test verifies the heat removal capability of the Low Head Safety Injection (LHSI) heat exchangers. The Frequency of 24 months on a STAGGERED TEST BASIS for each LHSI heat exchanger was developed considering the known reliability of closed cycle heat exchangers and other testing performed at shorter intervals that is intended to identify the possible loss of heat removal capability.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 35.
 2. 10 CFR 50.46.
 3. FSAR Section 6.2.
 4. FSAR Chapter 15.
 5. NRC Memorandum to V. Stello, Jr., from R.L. Baer, "Recommended Interim Revisions to LCOs for ECCS Components," December 1, 1975.
 6. ASME Code for Operation and Maintenance of Nuclear Power Plants.
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B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.3 ECCS - Shutdown, MODE 4

BASES

BACKGROUND The Background section for Bases 3.5.2, "ECCS - Operating," is applicable to these Bases, with the following modifications.

In MODE 4, a single ECCS train consisting of a Medium Head Safety Injection (MHSI) train is capable of providing the core cooling function. A second MHSI train is assumed to spill out of the break. Low Head Safety Injection (LHSI) is not automatically actuated.

The ECCS MHSI flow paths consist of piping, valves, and pumps such that water from the In-Containment Refueling Water Storage Tank (IRWST) can be injected into the Reactor Coolant System (RCS) following the accidents described in Bases 3.5.2.

APPLICABLE SAFETY ANALYSES The Applicable Safety Analyses section of Bases 3.5.2 also applies to this Bases section.

Due to the stable conditions associated with operation in MODE 4 and the reduced probability of occurrence of a Design Basis Accident (DBA), the ECCS operational requirements are reduced. Below P14 and RHR connected, LHSI is not automatically actuated by the Protection System (PS). However, MHSI is automatically actuated by the PS.

Three MHSI trains of ECCS are required for MODE 4.

The ECCS MHSI trains satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO In MODE 4, three of the four independent (and redundant) ECCS MHSI trains are required to be OPERABLE to ensure that sufficient ECCS flow is available to the core following a DBA. One MHSI train is required to accomplish the safety function, one MHSI train is lost due to single failure, and one MHSI train is assumed to feed the break.

In MODE 4, an ECCS train consists of an MHSI train. Each MHSI train includes the piping, instruments, and controls to ensure an OPERABLE flow path capable of taking suction from the IRWST.

BASES

LCO (continued)

During an event requiring ECCS MHSI actuation, a flow path is required to provide an abundant supply of water from the IRWST to the RCS via the MHSI pumps and to its associated cold leg injection nozzles.

APPLICABILITY

In MODES 1, 2, and 3, the OPERABILITY requirements for ECCS are covered by LCO 3.5.2.

In MODE 4, three OPERABLE ECCS MHSI trains are acceptable and provide for single failure consideration.

In MODES 5 and 6, the OPERABILITY requirements for ECCS are covered by LCO 3.5.8 "ECCS - Shutdown, MODES 5 and 6". Core cooling requirements in MODE 5 are addressed by LCO 3.4.7, "RCS Loops - MODE 5, Loops Filled," and LCO 3.4.8, "RCS Loops - MODE 5, Loops Not Filled." MODE 6 core cooling requirements are addressed by LCO 3.9.4, "RHR Loops - High Water Level," and LCO 3.9.5, "RHR Loops - Low Water Level."

ACTIONS

A Note prohibits the application of LCO 3.0.4.b to an inoperable ECCS MHSI train. There is an increased risk associated with entering MODE 4 from MODE 5 with an inoperable ECCS MHSI train and the provisions of LCO 3.0.4.b, which allow entry into a MODE or other specified condition in the Applicability with the LCO not met after performance of a risk assessment addressing inoperable systems and components, should not be applied in this circumstance.

A.1

With one required MHSI train inoperable, the inoperable MHSI train must be returned to OPERABLE status within 72 hours. The 72 hour Completion Time is based on an NRC reliability evaluation (Ref. 5) and is a reasonable time for repair of many ECCS components.

An ECCS MHSI train is inoperable if it is not capable of delivering design flow to the RCS. Individual components are inoperable if they are not capable of performing their design function or supporting systems are not available.

BASES

ACTIONS (continued)

B.1

When Required Action A.1 cannot be completed within the required Completion Time; or if two required ECCS MHSI trains are inoperable, the unit must be placed in a MODE in which the LCO does not apply. To achieve this status, the unit must be placed in MODE 5 within 12 hours.

The allowed Completion Time is reasonable, based on operating experience, to reach the required unit conditions from MODE 4 in an orderly manner and without challenging plant systems.

SURVEILLANCE
REQUIREMENTS

SR 3.5.3.1

The applicable Surveillance descriptions from Bases 3.5.2 apply.

REFERENCES

The applicable references from Bases 3.5.2 apply.

B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.4 In-Containment Refueling Water Storage Tank (IRWST) - Operating

BASES

BACKGROUND The IRWST supplies borated water to the refueling pool during refueling, and to the ECCS during accident conditions.

The IRWST supplies all four trains of the ECCS through separate, independent supply headers during the injection phase of a loss of coolant accident (LOCA) recovery.

During normal operation in MODES 1, 2, and 3, Medium Head Safety Injection (MHSI) and Low Head Safety Injection (LHSI) pumps are aligned to take suction from the IRWST.

The ECCS pumps are provided with recirculation lines that ensure each pump can maintain minimum flow requirements when operating at or near shutoff head conditions.

This LCO ensures that:

- a. The IRWST contains sufficient borated water to support the ECCS accident mitigation function; and
- b. The reactor remains subcritical following a LOCA.

Insufficient water in the IRWST could result in insufficient cooling capacity and suction head for ECCS operation. Improper boron concentrations or enrichment could result in a reduction of SDM or excessive boric acid precipitation in the core following the LOCA, as well as excessive caustic stress corrosion of mechanical components and systems inside the containment.

APPLICABLE SAFETY ANALYSES During accident conditions, the IRWST provides a source of borated water to the ECCS pumps. As such, it provides containment energy removal, core cooling, and replacement inventory and is a source of negative reactivity for reactor shutdown (Ref. 1). The design basis transients and applicable safety analyses concerning the ECCS is discussed in the Applicable Safety Analyses section of B 3.5.2, "ECCS - Operating," and B 3.5.3, "ECCS – Shutdown MODE 4." These analyses are used to assess changes to the IRWST in order to evaluate their effects in relation to the acceptance limits in the analyses.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The IRWST must also meet volume, boron concentration, boron isotopic inventory (i.e., enrichment), and temperature requirements for non-LOCA events. The volume is not an explicit assumption in non-LOCA events since the required volume is a small fraction of the available volume. The deliverable volume limit is set by the required volumes for an outage and is therefore not limiting. The minimum IRWST provides sufficient water depth for ECCS pump NPSH requirements.

The maximum temperature ensures that the amount of cooling provided from the IRWST during the heatup phase of a feedline break is consistent with safety analysis assumptions; the minimum is an assumption in the MSLB analysis.

For a large break LOCA analysis, the minimum water volume of 500,342 gallons and the lower boron concentration limit of 1700 ppm of $\geq 37\%$ enriched boron are used to compute the post LOCA sump boron concentration necessary to assure subcriticality. The large break LOCA is the limiting case since the safety analysis assumes that all control rods are out of the core. This minimum volume bounds the ECCS pump NPSH requirements.

The purpose of switching a portion of the LHSI flow from cold leg to hot leg injection is to reduce containment pressure and temperature following the accident. This also serves to backflush the loops, reduce the boiling in the top of the core, and recapture any boron precipitation.

The upper temperature limit of 122°F is used in the small break LOCA analysis and containment OPERABILITY analysis. Exceeding this temperature will result in a higher peak clad temperature, because there is less heat transfer from the core to the injected water for the small break LOCA. For the containment response following an MSLB, the lower limit on boron concentration and the upper limit on IRWST water temperature are used to maximize the total energy release to containment.

The minimum temperature value of 59°F is consistent with mechanical requirements, particularly reactor pressure vessel brittle fracture risk.

The IRWST satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii).

BASES

LCO The IRWST ensures that an adequate supply of borated water is available to cool and depressurize the containment in the event of a Design Basis Accident (DBA), to cool and cover the core in the event of a LOCA, to maintain the reactor subcritical following a DBA, and to ensure adequate level in the containment sump to support ECCS pump operation.

To be considered OPERABLE, the IRWST must meet the valve position, temperature, water volume, and boron concentration and enrichment limits established in the SRs.

APPLICABILITY In MODES 1, 2, 3, and 4, IRWST OPERABILITY requirements are dictated by ECCS OPERABILITY requirements. Since the ECCS must be OPERABLE in MODES 1, 2, 3, and 4, the IRWST must also be OPERABLE to support its operation. Core cooling requirements in MODE 5 are addressed by LCO 3.4.7, "RCS Loops - MODE 5, Loops Filled," and LCO 3.4.8, "RCS Loops - MODE 5, Loops Not Filled." The requirements for the IRWST in MODE 5 are specified in LCO 3.5.6, "In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 5." MODE 6 core cooling requirements are addressed by LCO 3.9.4, "RHR Loops - High Water Level," and LCO 3.9.5, "RHR Loops - Low Water Level." The requirements for the IRWST in MODE 6 are specified in LCO 3.5.7, "In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 6."

ACTIONS A.1

With IRWST temperature, water volume, boron concentration, or enrichment not within limits, it must be returned to within limits within 8 hours. Under these conditions the ECCS cannot perform its design function. Therefore, prompt action must be taken to restore the tank to OPERABLE condition. The 8 hour limit is acceptable considering that the IRWST will be fully capable of performing its assumed safety function in response to DBAs with slight deviations in these parameters.

BASES

ACTIONS (continued)

B.1

With one or more motor-operated passive flooding line valves not closed or with power not removed from the valve operator, a portion of the IRWST inventory could become unavailable to the ECCS pumps. In this situation, the valves must be restored to the closed position with power removed from the valve operator in one hour. This Completion Time is acceptable based on risk considerations.

C.1 and C.2

If the IRWST cannot be returned to OPERABLE status within the associated Completion Time, 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 at least MODE 3 within 6 hours and to MODE 5 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE
REQUIREMENTS

SR 3.5.4.1

This surveillance requires verification each motor-operated passive flooding line valve is closed and that power is removed from each valve operator. This surveillance may be performed with available remote position indication instrumentation. The 12 hour Frequency is acceptable, considering the available remote indication and alarms.

SR 3.5.4.2

The IRWST borated water temperature should be verified every 24 hours to be within the limits assumed in the accident analyses band. This Frequency is sufficient to identify a temperature change that would approach either limit and has been shown to be acceptable through operating experience.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.4.3

The IRWST water volume should be verified every 7 days to be within limits. The required minimum volume is verified in order to ensure that a sufficient NPSH is available for injection and to support continued ECCS pump operation. The maximum volume is verified in order to ensure the value assumed in the post-LOCA boron precipitation evaluation is not exceeded. Since the IRWST volume is normally stable and is protected by an alarm, a 7 day Frequency is appropriate and has been shown to be acceptable through operating experience.

SR 3.5.4.4

The boron concentration of the IRWST should be verified every 7 days to be within the required limits. This SR ensures that the reactor will remain subcritical following a LOCA. Further, it assures that the resulting sump pH will be maintained in an acceptable range so that boron precipitation in the core will not occur and the effect of chloride and caustic stress corrosion on mechanical systems and components will be minimized.

Since the IRWST inventory is normally stable, a 7 day sampling Frequency to verify boron concentration is appropriate and has been shown to be acceptable through operating experience.

SR 3.5.4.5

The boron used in the IRWST is enriched to $\geq 37\%$ in the B-10 isotope. Verification every 24 months that the B-10 enrichment is $\geq 37\%$ ensures that the B-10 concentration assumed in the accident analysis is available. Since B-10 in the IRWST is not exposed to a significant neutron field, 24 months is considered conservative.

REFERENCES

1. FSAR Chapter 6 and Chapter 15.
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B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.5 Extra Borating System (EBS)

BASES

BACKGROUND The EBS is a manually actuated, safety-related system that is used in the mitigation of design basis accidents, including a steam generator tube rupture (SGTR). During this event, the EBS injects boron into the Reactor Coolant System (RCS) to maintain the core subcritical while the RCS is being cooled to the point where the Low Head Safety Injection System can be connected to remove core decay heat. The EBS also provides RCS makeup to balance a portion of the shrinkage during cooldown. The EBS can be used for hydrostatic testing of the RCS but otherwise does not perform any function supporting normal plant operation.

The EBS consists of two identical trains. Each train is composed of its own boron tank, a high pressure 100% capacity pump, a test line, and injection lines to the RCS. The volume of concentrated boric acid required to maintain subcriticality is divided between the two EBS tanks. A common suction header allows either EBS pump to take suction from both tanks. The boron tanks and the primary train lines are filled with borated water and are located in a temperature controlled room to prevent crystallization of the boron (Ref. 1). Outside of the temperature controlled rooms, the EBS piping is filled with lower concentration borated water from the In-Containment Refueling Water Storage Tank.

APPLICABLE SAFETY ANALYSES If needed, the EBS is manually initiated. A 30 minute operator action time is assumed in the analysis (Ref. 2). Once started for safety reasons, the EBS will remain in operation until the boron concentration needed for cold shutdown is reached.

The EBS is initiated for an SGTR to ensure adequate boration to prevent criticality. The contents of the EBS are not credited for core cooling or immediate boration in the Loss of Coolant Accident (LOCA) analysis. The EBS maximum boron concentration of 7300 ppm is used in the Boron Precipitation Assessment (Ref. 2). The minimum boron concentration of 7000 ppm is credited in the SGTR analysis and for cooldown from other design basis events. Boron used in the EBS is enriched to $\geq 37\%$ in the B-10 isotope.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The EBS minimum water volume limit of 2372 ft³ total between the two EBS tanks is used to ensure that the appropriate quantity of highly borated water with sufficient negative reactivity is injected into the RCS to maintain the core in a shutdown condition following an SGTR or during cooldown for other Design Basis Accidents (DBAs). This volume includes approximately 189 ft³ of unusable volume in each tank.

The minimum temperature limit of 68°F for the EBS borated water assures that the solution does not reach the point of boron crystallization.

The EBS satisfies Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

This LCO establishes the minimum requirements as well as requirements for contained volume, boron concentration, boron enrichment, and temperature of the EBS inventory (Ref. 3). This ensures that an adequate supply of borated water is available in the event of an SGTR or other design basis event to maintain the reactor subcritical following these accidents.

To be considered OPERABLE, the limits established in the SR for water volume, boron concentration, boron isotopic inventory, and temperature must be met.

APPLICABILITY

In MODES 1, 2, 3, and 4, the EBS is needed to maintain the core subcritical following an SGTR and during cooldown to MODE 5 for DBAs.

An SGTR and other DBAs that rely on the EBS for cooldown are not postulated in MODES 5, and 6 and EBS OPERABILITY is not required.

ACTIONS

A.1

If the boron concentration or boron enrichment of one or both EBS tanks is not within limits, it must be returned to within limits within 72 hours. Because of the low probability of an SGTR or other DBAs, the allowed Completion Time of 72 hours is acceptable and provides adequate time to restore concentration or enrichment to within limits.

Boron concentration or boron enrichment can be restored within the 72 hour limit by mixing fresh boric acid in the Reactor Boron and Water Makeup System (RBWMS) and transferring it to the EBS tanks.

BASES

ACTIONS (continued)

B.1

If one EBS train is inoperable for reasons other than Condition A, the inoperable train must be restored to OPERABLE status within 7 days. In this condition, the remaining OPERABLE train is adequate to perform the shutdown function. However, the overall reliability is reduced because a single failure in the remaining OPERABLE train could result in reduced EBS shutdown capability. The 7 day Completion Time is based on the availability of an OPERABLE train capable of performing the intended EBS function and the low probability of a DBA occurring.

Certain failure modes of EBS could affect one or both trains of EBS since 100% of the volume of concentrated boric acid required to maintain subcriticality is divided between the two EBS tanks. Both tanks are needed to maintain OPERABILITY. Since the two EBS tanks are interconnected through a normally open flow path that allows either EBS pump to draw from both tanks, failure modes of EBS must consider if both trains are affected. Failure of active mechanical components such as the pump or motor operated valves would only affect one train and can be restored within the 7 day limit.

C.1

If both EBS trains are inoperable for reasons other than Condition A, 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 occurring.

Certain failure modes of EBS could affect one or both trains of EBS. Since 100% of the volume of concentrated boric acid required to maintain subcriticality is divided between the two EBS tanks is needed to maintain OPERABILITY. Since the two EBS tanks are interconnected through a normally open flow path that allows either EBS pump to draw from both tanks, failure modes of EBS must consider if both trains are affected.

A decrease in volume would affect both trains. The likely causes of the EBS tank volume decreasing below limits are leakage, sampling, or testing. The margin for EBS tank volume would make it unlikely that such a decrease in volume would occur without detection. Fresh concentrated boric acid can be supplied from the Reactor Boron Water Makeup System (RBWMS) and volume can be restored within the 8 hour limit.

BASES

ACTIONS (continued)

The likely cause of the EBS tank temperature decreasing below limits is abnormally low outside ambient temperature coupled with a failure in the safety-related portion of the Fuel Building Ventilation System to maintain EBS room temperatures. The margin for EBS tank temperature to decrease before boron precipitation begins allows a reasonable time to either restore the Fuel Building Ventilation System or start the EBS pump to allow recirculation to heat the EBS tank and temperature can be restored within the 8 hour limit.

D.1 and D.2

If any Required Action and associated Completion Time is not met, the unit must be brought to a MODE in which the LCO does not apply. To achieve this status, the unit must be brought to MODE 3 within 6 hours and MODE 5 within 36 hours.

The allowed Completion Times are reasonable, based on operating experience, to reach MODE 5 from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.5.5.1

Verification every 24 hours that each EBS tank water temperature and EBS pump room is at or above the specified minimum temperature is frequent enough to identify a temperature change that would approach the acceptable limit. The solution temperature is also monitored by an alarm that provides further assurance of protection against low temperature. This Frequency has been shown to be acceptable through operating experience.

The EBS is designed to prevent boric acid crystallization during standby without heat tracing. The temperature inside the Fuel Building where the tanks and main lines are located is maintained above 68°F by safety-related portion of the Fuel Building Ventilation System.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.5.2

Verification every 7 days that the EBS contained volume is above the required limit is frequent enough to assure that this volume will be available for quick injection into the RCS. If the volume is too low, the EBS would not provide enough borated water to ensure subcriticality during recirculation. Since the EBS volume is normally stable, a 7 day Frequency is appropriate and has been shown to be acceptable through operating experience.

SR 3.5.5.3

The boron concentration should be verified to be within required limits for each tank every 31 days since the static design of the EBS tanks limits the ways in which the concentration can be changed. The 31 day Frequency is adequate to identify changes that could occur from mechanisms such as stratification or in-leakage. This surveillance must also be performed anytime water or boron are added to a tank and anytime the temperature is restored to within its limit to ensure no significant boron precipitation has occurred.

SR 3.5.5.4

Verifying the correct alignment for manual and power operated valves in the EBS flow paths provides assurance that the proper flow paths will exist for EBS operation. This SR does not apply to valves that are locked, sealed, or otherwise secured in position, since these were verified to be in the correct position prior to locking, sealing, or securing. This Surveillance does not require any testing or valve manipulation. Rather, it involves verification that those valves capable of being mispositioned are in the correct position. The 31 day Frequency is appropriate because the valves are operated under administrative control, and an improper valve position would only affect a single train. This Frequency has been shown to be acceptable through operating experience.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.5.5

Demonstrating each EBS pump develops a flow rate ≥ 49.0 gpm and ≤ 55.4 gpm ensures that pump performance has not degraded during the fuel cycle. This minimum pump flow rate requirement ensures that the core will remain subcritical during and after a cooldown following design basis accidents including an SGTR. The maximum flow rate to the RCS is needed so that the pressurizer is not filled which could actuate the pressurizer relief valves. This inservice test confirms EBS pump OPERABILITY, trends performance, and detects incipient failures by indicating abnormal performance. The Frequency of this Surveillance is in accordance with the Inservice Testing Program.

SR 3.5.5.6

The boron used in each EBS tank is enriched to $\geq 37\%$ in the B-10 isotope. Verification every 24 months that the B-10 enrichment is $\geq 37\%$ ensures that the B-10 concentration assumed in the accident analysis is available. Since B-10 in the EBS is not exposed to a significant neutron field, 24 months is considered conservative.

SR 3.5.5.7

This Surveillance ensures that there is a functioning flow path from the EBS tank to the RCS. An acceptable method is to test the flow path in several separate tests. The 24 month Frequency is based on the need to perform this Surveillance under conditions that apply during a unit outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the Surveillance test when performed at the 24 month Frequency; therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.5.5.8

The 24 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass this Surveillance when performed at the 24 month Frequency. The 24 month Frequency is based on engineering judgment and is considered adequate given that the isolation is not challenged during a SGTR and power operated outboard containment isolation valve can be de-energized and opened manually. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

REFERENCES

1. FSAR Section 6.8.
 2. FSAR Section 15.6.3.
 3. 10 CFR 50.46.
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B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.6 In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 5

BASES

BACKGROUND A description of the IRWST is provided in LCO 3.5.4, "In-Containment Refueling Water Storage Tank - Operating."

APPLICABLE SAFETY ANALYSES For postulated shutdown events in MODE 5 with the Reactor Coolant System (RCS) pressure boundary intact, the primary protection is the Medium Head Safety Injection (MHSI) trains, where the IRWST serves as the source of borated water. For events in MODE 5 with the RCS pressure boundary open, RCS heat removal is provided by MHSI injection of borated water from the IRWST.

No loss of coolant accidents (LOCAs) are postulated during plant operation in MODE 5. However, the IRWST is available to minimize the probability and consequence of an event to the extent possible.

The IRWST in MODE 5 satisfies Criteria 4 of 10 CFR 50.36 (c)(2)(ii).

LCO The IRWST requirements ensure that an adequate supply of borated water is available to supply the required volume of borated water as safety injection for core cooling and reactivity control.

To be considered OPERABLE, the IRWST must meet the valve position, water volume, boron concentration and boron enrichment limits defined in the Surveillance Requirements.

APPLICABILITY In MODE 5 with the RCS pressure boundary intact or with the RCS open, the IRWST is an RCS injection source of borated water for core cooling and reactivity control.

The requirements for the IRWST in MODES 1, 2, 3 and 4 are specified in LCO 3.5.4, "In-Containment Refueling Water Storage Tank (IRWST) - Operating." The requirements for the IRWST in MODE 6 are specified in LCO 3.5.7, "In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 6."

BASES

ACTIONS

A.1

With IRWST water volume, boron concentration, or enrichment not within limits, it must be returned to within limits within 8 hours. Under these conditions the ECCS cannot perform its design function. Therefore, prompt action must be taken to restore the tank to OPERABLE condition. The 8 hour limit is acceptable considering that the IRWST will be fully capable of performing its assumed safety function in response to DBAs with slight deviations in these parameters.

B.1

With one or more motor-operated passive flooding line valves not closed or with power not removed from the valve operator, a portion of the IRWST inventory could become unavailable to the ECCS pumps. In this situation, the valves must be restored to the closed position with power removed from the valve operator in one hour. This Completion Time is acceptable based on risk considerations.

C.1 and C.2

If the IRWST cannot be returned to OPERABLE status within the associated Completion Time of Condition A or B, the plant must be placed in a condition in which the probability and consequences of an event are minimized to the extent possible. This is done by immediately initiating action to ensure the RCS boundary is intact with $\geq 25\%$ pressurizer level. This provides adequate RCS inventory in support of RHR cooling. Additionally, action to suspend positive reactivity additions is required to ensure that the SDM is maintained. Sources of positive reactivity addition include boron dilution, withdrawal of rod cluster control assemblies, and excessive cooling of the RCS.

BASES

SURVEILLANCE
REQUIREMENTS

SR 3.5.6.1

The LCO 3.5.4 Surveillance Requirements and Frequencies (SR 3.5.4.1, SR 3.5.4.3, and 3.5.4.4) are applicable to the IRWST in MODE 5. Refer to the corresponding Bases for LCO 3.5.4 for a discussion of each SR.

REFERENCES

None

B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.7 In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 6

BASES

BACKGROUND A description of the IRWST is provided in LCO 3.5.4, "In-Containment Refueling Water Storage Tank - Operating."

APPLICABLE SAFETY ANALYSES For postulated shutdown events in MODE 6, RCS heat removal is provided by injection of borated water from the IRWST by Medium Head Safety Injection (MHSI).

The IRWST in MODE 6 satisfies Criteria 4 of CFR 50.36 (c)(2)(ii).

LCO The IRWST requirements ensure that an adequate supply of borated water is available to supply the required volume of borated water as safety injection for cool cooling.

To be considered OPERABLE, the IRWST in combination with the refueling canal must meet the valve position and water volume limits defined in the Surveillance Requirements. Any canal leakage should be estimated and made up with borated water such that the volume in the IRWST plus the refueling canal and refueling cavity will meet the IRWST volume requirement.

Boron concentration requirements are addressed by LCO 3.9.1

APPLICABILITY In MODE 6, the IRWST is the MHSI injection source of borated water for core cooling. Once the refueling cavity is filled, the IRWST is no longer required as an injection source.

The requirements for the IRWST in MODES 1, 2, 3, and 4 are specified in LCO 3.5.4, "In-Containment Refueling Water Storage Tank (IRWST) - Operating." The requirements for the IRWST in MODE 5 are specified in LCO 3.5.6, "In-Containment Refueling Water Storage Tank (IRWST) - Shutdown, MODE 5."

BASES

ACTIONS

A.1

With IRWST water volume not within limit, it must be returned to within limit within 8 hours. Under these conditions the ECCS cannot perform its design function. Therefore, prompt action must be taken to restore the tank to OPERABLE condition. The 8 hour limit is acceptable considering that the IRWST will be fully capable of performing its assumed safety function in response to DBAs with slight deviations in these parameters.

B.1

With one or more motor-operated passive flooding line valves not closed or with power not removed from the valve operator, a portion of the IRWST inventory could become unavailable to the ECCS pumps. In this situation, the valves must be restored to the closed position with power removed from the valve operator in one hour. This Completion Time is acceptable based on risk considerations.

C.1 and C.2

If the IRWST cannot be returned to OPERABLE status within the associated Completion Times, the plant must be placed in a condition in which the probability and consequences of an event are minimized to the extent possible. In MODE 6, action must be immediately initiated to be in MODE 6 with the water level ≥ 23 feet above the top of the reactor vessel flange.

The time to RCS boiling is maximized by maximizing the RCS inventory and maintaining RCS temperatures as low as practical. Additionally, action to suspend positive reactivity additions is required to ensure that the SDM is maintained. Sources of positive reactivity addition include boron dilution, withdrawal of rod cluster control assemblies, and excessive cooling of the RCS. These actions place the plant in a condition which maximized the time to IRWST injection, thus providing time for repairs or application of alternative cooling capabilities.

BASES

SURVEILLANCE
REQUIREMENTS

SR 3.5.7.1

The IRWST should be verified every 24 hours to be within limits. The required minimum volume is verified in order to ensure that a sufficient NPSH is available for injection and to support continued ECCS pump operation. Since the IRWST volume is normally stable and is protected by an alarm, a 24 hour Frequency is appropriate and has been shown to be acceptable through operating experience

SR 3.5.7.2

The LCO 3.5.4 Surveillance Requirement and Frequency (SR 3.5.4.1) is applicable to the IRWST in MODE 6. Refer to the corresponding Bases for LCO 3.5.4 for a discussion of the SR.

REFERENCES

None

B 3.5 EMERGENCY CORE COOLING SYSTEMS (ECCS)

B 3.5.8 ECCS - Shutdown, MODES 5 and 6

BASES

BACKGROUND	<p>The Background section for Bases 3.5.2, "ECCS - Operating," is applicable to these Bases, with the following modifications.</p> <p>In MODES 5 and 6, a single ECCS train consisting of a Medium Head Safety Injection (MHSI) train is capable of providing the core cooling function. Low head Safety Injection is not automatically actuated.</p> <p>The ECCS MHSI flow paths consist of piping, valves, and pumps such that water from the In-Containment Refueling Water Storage Tank (IRWST) can be injected into the Reactor Coolant System (RCS) following loss of shutdown cooling event.</p>
APPLICABLE SAFETY ANALYSES	<p>The Applicable Safety Analyses section of Bases 3.5.2 also applies to this Bases section.</p> <p>Due to the stable conditions and low RCS pressure associated with operation in MODES 5 and 6 and the reduced probability of occurrence of a shutdown event, the ECCS operational requirements are reduced. Below P14 and RHR connected, LHSI is not automatically actuated by the Protection System (PS). However, MHSI is automatically actuated by the PS.</p> <p>Two MHSI trains of ECCS are required for MODES 5 and 6. Protection against single failures is provided for this MODE of operation.</p> <p>The ECCS MHSI trains in MODES 5 and 6 satisfy Criteria 4 of 10 CFR 50.36(c)(2)(ii).</p>
LCO	<p>In MODES 5 and 6, two of the four independent (and redundant) ECCS MHSI trains are required to be OPERABLE to ensure that sufficient ECCS flow is available to the core following shutdown events. One MHSI train is required to accomplish the safety function and one MHSI train is assumed lost to a single failure.</p> <p>In MODES 5 and 6, an ECCS train consists of an MHSI train. Each MHSI train includes the piping, instruments, and controls to ensure an OPERABLE flow path capable of taking suction from the IRWST.</p>

BASES

LCO (continued)

During an event requiring ECCS MHSI actuation, a flow path is required to provide an abundant supply of water from the IRWST to the RCS via the ECCS pumps and to its associated four cold leg injection nozzles.

APPLICABILITY

In MODES 1, 2, and 3, the OPERABILITY requirements for ECCS are covered by LCO 3.5.2. MODE 4 OPERABILITY is covered by LCO 3.5.3.

In MODES 5 and 6, two OPERABLE ECCS MHSI trains are acceptable and provide for single failure consideration.

Core cooling requirements in MODE 5 are addressed by LCO 3.4.7, "RCS Loops - MODE 5, Loops Filled," and LCO 3.4.8, "RCS Loops - MODE 5, Loops Not Filled." MODE 6 core cooling requirements are addressed by LCO 3.9.4, "RHR Loops - High Water Level," and LCO 3.9.5, "RHR Loops - Low Water Level."

ACTIONS

A.1

With one required MHSI train inoperable, the inoperable MHSI train must be returned to OPERABLE status within 72 hours. The 72 hour Completion Time is based on an NRC reliability evaluation (Ref. 5) and is a reasonable time for repair of many ECCS components.

An ECCS MHSI train is inoperable if it is not capable of delivering design flow to the RCS. Individual components are inoperable if they are not capable of performing their design function or supporting systems are not available.

B.1

If two required ECCS MHSI trains are inoperable, immediate action must be taken to restore at least one MHSI train to OPERABLE status.

BASES

ACTIONS (continued)

C.1 and C.2

If any Required Action and associated Completion Time cannot be met, the plant must be placed in a condition in which the probability and consequences of an event are minimized to the extent possible. This is done by immediately initiating action to place the plant in MODE 5 with the RCS intact with $\geq 25\%$ pressurizer level or, if in MODE 6, to achieve refueling cavity water level ≥ 23 feet above the reactor vessel flange. This provides adequate RCS inventory in support of RHR cooling. Additionally, action to suspend positive reactivity additions is required to ensure that the SDM is maintained. Sources of positive reactivity addition include boron dilution, withdrawal of rod cluster control assemblies, and excessive cooling of the RCS.

SURVEILLANCE
REQUIREMENTS

SR 3.5.8.1

The applicable Surveillance descriptions from Bases 3.5.2 apply.

REFERENCES

The applicable references from Bases 3.5.2 apply.
