BORATED WATER SOURCE - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.2.5 As a minimum, one of the following borated water sources shall be OPERABLE:

a. A boric acid storage system with:

1. A minimum contained borated water volume of 2700 gallons,

2. Between 7000 and 7700 ppm of boron, and

3. A minimum solution temperature of 65°F.

b. The refueling water storage tank with:

1. A minimum contained borated water volume of 37,900 gallons,

2. A minimum boron concentration of ~~2000~~ 2300 ppm, and

3. A minimum solution temperature of 40°F.

APPLICABILITY: MODES 5 and 6.

ACTION:

With no borated water source OPERABLE, suspend all operations involving CORE ALTERATIONS or positive reactivity changes.

SURVEILLANCE REQUIREMENTS

4.1.2.5 The above required borated water source shall be demonstrated OPERABLE:

a. At least once per 7 days by:

1. Verifying the boron concentration of the water,

2. Verifying the contained borated water volume, and

3. Verifying the boric acid storage tank solution temperature when it is the source of borated water.

b. At least once per 24 hours by verifying the RWST temperature when it is the source of borated water and the outside air temperature is less than 40°F.

ATTACHMENT I
Page 1of 9

BORATED WATER SOURCES - OPERATING

LIMITING CONDITION FOR OPERATION

3.1.2.6 As a minimum, the following borated water source(s) shall be OPERABLE as required by Specification 3.1.2.2:

a. A boric acid storage system with:

1. A minimum contained borated water volume of 13,200 gallons,

2. Between 7000 and 7700 ppm of boron, and

3. A minimum solution temperature of 65°F.

b. The refueling water storage tank with:

1. A minimum contained borated water volume of 453,800 gallons,

2. ~~Between 2000 and 2100 ppm of boron, and~~ A minimum boron concentration of 2300 ppm, and

3. A minimum solution temperature of 40°F.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

a. With the boric acid storage system inoperable and being used as one of the above required borated water sources, restore the storage system to OPERABLE status within 72 hours or be in at least HOT STANDBY within the next 6 hours and borated to a SHUTDOWN MARGIN equivalent to at least 2 percent delta k/k at 200°F; restore the boric acid storage system to OPERABLE status within the next 7 days or be in COLD SHUTDOWN within the next 30 hours.

b. With the refueling water storage tank inoperable, restore the tank to OPERABLE status within one hour or be in at least HOT STANDBY within the next 6 hours and in COLD SHUTDOWN within the following 30 hours.

3/4.5 EMERGENCY CORE COOLING SYSTEMS

3/4.5.1 ACCUMULATORS

LIMITING CONDITION FOR OPERATION

3.5.1 Each reactor coolant system accumulator shall be OPERABLE with:

a. The isolation valve open,

b. A contained borated water volume of between 7368 and 7594 gallons,

c. A boron concentration of between ~~1900~~ 2200 and ~~2100~~ 2500 ppm, and

d. A nitrogen cover-pressure of between 600 and 656 psig.

APPLICABILITY: MODES 1, 2 and 3.*

ACTION:

a. With one accumulator inoperable, except as a result of a closed isolation valve, restore the inoperable accumulator to OPERABLE status within one hour or be in at least HOT STANDBY within the next 6 hours and in HOT SHUTDOWN within the following 6 hours.

b. With one accumulator inoperable due to the isolation valve being closed, either immediately open the isolation valve or be in at least HOT STANDBY within one hour and in HOT SHUTDOWN within the following 12 hours.

SURVEILLANCE REQUIREMENTS

4.5.1.1 Each accumulator shall be demonstrated OPERABLE:

a. At least once per 12 hours by:

1. Verifying the contained borated water volume and nitrogen cover-pressure in the tanks, and

2. Verifying that each accumulator isolation valve is open.

*Pressurizer pressure above 1000 psig.

3/4.5.4 REFUELING WATER STORAGE TANK

LIMITING CONDITION FOR OPERATION

3.5.5 The refueling water storage tank (RWST) shall be OPERABLE with:

a. A minimum contained borated water volume of 453,800 gallons,

b. A boron concentration of between ~~2000~~ 2300 and ~~2100~~ 2500 ppm of boron, and

c. A minimum water temperature of 40°F.

APPLICABILITY: MODES 1, 2, 3 and 4.

ACTION:

With the refueling water storage tank inoperable, restore the tank to OPERABLE status within 1 hour or be in at least HOT STANDBY within 6 hours and in COLD SHUTDOWN within the following 30 hours.

SURVEILLANCE REQUIREMENTS

4.5.5 The RWST shall be demonstrated OPERABLE:

a. At least once per 7 days by:

1. Verifying the contained borated water volume in the tank, and

2. Verifying the boron concentration of the water.

b. At least once per 24 hours by verifying the RWST temperature when the outside air temperature is less than 40°F.

MODERATOR TEMPERATURE COEFFICIENT (Continued)

involved subtracting the incremental change in the MDC associated with a core condition of all rods inserted (most positive MDC) to an all rods withdrawn condition and, a conversion for the rate of change of moderator density with temperature at RATED THERMAL POWER conditions. This value of the MDC was then transformed into the limiting MTC value -4.2×10^{-4} delta k/k/°F. The MTC value of -3.3×10^{-4} delta k/k/°F represents a conservative value (with corrections for burnup and soluble boron) at a core condition of 300 ppm equilibrium boron concentration and is obtained by making these corrections to the limiting MTC value of -4.2×10^{-4} k/k/°F.

The surveillance requirements for measurement of the MTC at the beginning and near the end of the fuel cycle are adequate to confirm that the MTC remains within its limits since this coefficient changes slowly due principally to the reduction in RCS boron concentration associated with fuel burnup.

3/4.1.1.4 MINIMUM TEMPERATURE FOR CRITICALITY

This specification ensures that the reactor will not be made critical with the Reactor Coolant System average temperature less than 551°F. This limitation is required to ensure 1) the moderator temperature coefficient is within its analyzed temperature range, 2) the protective instrumentation is within its normal operating range, 3) the pressurizer is capable of being in an OPERABLE status with a steam bubble, and 4) the reactor pressure vessel is above its minimum RT_{NDT} temperature.

3/4.1.2 BORATION SYSTEMS

The boron injection system ensures that negative reactivity control is available during each mode of facility operation. The components required to perform this function include 1) borated water sources, 2) charging pumps, 3) separate flow paths, 4) boric acid transfer pumps, and 5) an emergency power supply from OPERABLE diesel generators.

With the RCS average temperature above 200°F, a minimum of two boron injection flow paths are required to ensure single functional capability in the event an assumed failure renders one of the flow paths inoperable. The boration capability of either flow path is sufficient to provide ~~a~~ SHUTDOWN

the required

IS SATISFIED BY

OR AS REQUIRED BY FIGURE 3.1-3

BORATION SYSTEMS (Continued)

MARGIN from expected operating conditions of 1.77% delta k/k after xenon decay and cooldown to 200°F. The maximum expected boration capability requirement occurs ~~at EOL~~ from full power equilibrium xenon conditions and ~~requires~~ 12475 gallons of 7000 ppm borated water from the boric acid storage tanks or 64,040 gallons of ~~2000~~ 2300 ppm borated water from the refueling water storage tank.

With the RCS temperature below 200°F, one injection system is acceptable without single failure consideration on the basis of the stable reactivity condition of the reactor and the additional restrictions prohibiting CORE ALTERATIONS and positive reactivity changes in the event the single injection system becomes inoperable.

The limitation for a maximum of one centrifugal charging pump to be OPERABLE and the Surveillance Requirement to verify all charging pumps except the required OPERABLE pump to be inoperable below 275°F provides assurance that a mass addition pressure transient can be relieved by the operation of a single PORV.

1 OR AS REQUIRED BY FIGURE 3.1-3 the REQUIRED

The boron capability required below 200°F is sufficient to provide ~~a~~ SHUTDOWN MARGIN ~~of 2~~ percent delta k/k after xenon decay and cooldown from 200°F to 140°F. This condition ~~requires~~ either 2000 gallons of 7000 ppm borated water from the boric acid storage tanks or 9690 gallons of ~~2000~~ 2300 ppm borated water from the refueling water storage tank.

IS SATISFIED BY

The contained water volume limits include allowance for water not available because of discharge line location and other physical characteristics.

~~The limits on contained water volume and boron concentration of the RWST also ensure a pH value of between 8.5 and 11.0 for the solution recirculated within containment after a LOCA. This pH band minimizes the evolution of iodine and minimizes the effect of chloride and caustic stress corrosion on mechanical systems and components.~~

The OPERABILITY of one boron injection system during REFUELING ensures that this system is available for reactivity control while in MODE 6.

3/4.1.3 MOVABLE CONTROL ASSEMBLIES

The specifications of this section ensure that (1) acceptable power distribution limits are maintained, (2) the minimum SHUTDOWN MARGIN is maintained, and (3) limit the potential effects of rod misalignment on associated accident analyses. OPERABILITY of the control rod position indicators is required to determine control rod positions and thereby ensure compliance with the control rod alignment and insertion limits.

ECCS SUBSYSTEMS (Continued)

The limitation for a maximum of one centrifugal charging pump to be OPERABLE and the Surveillance Requirement to verify all charging pumps except the required OPERABLE charging pump to be inoperable below 300°F provides assurance that a mass addition pressure transient can be relieved by the operation of a single PORV.

The Surveillance Requirements provided to ensure OPERABILITY of each component ensures that at a minimum, the assumptions used in the safety analyses are met and that subsystem OPERABILITY is maintained. Surveillance requirements for throttle valve position stops and flow balance testing provide assurance that proper ECCS flows will be maintained in the event of a LOCA. Maintenance of proper flow resistance and pressure drop in the piping system to each injection point is necessary to: (1) prevent total pump flow from exceeding runout conditions when the system is in its minimum resistance configuration, (2) provide the proper flow split between injection points in accordance with the assumptions used in the ECCS-LOCA analyses, and (3) provide an acceptable level of total ECCS flow to all injection points equal to or above that assumed in the ECCS-LOCA analyses.

3/4.5.4 REFUELING WATER STORAGE TANK

The OPERABILITY of the Refueling Water Storage Tank (RWST) as part of the ECCS ensures that a sufficient supply of borated water is available for injection by the ECCS in the event of a LOCA. ~~The limits on RWST minimum volume and boron concentration ensure that 1) sufficient water is available within containment to permit recirculation cooling flow to the core, and 2) the reactor will remain subcritical in the cold condition following mixing of the RWST and the RCS water volumes with all control rods inserted except for the most reactive control assembly. These assumptions are consistent with the LOCA analyses.~~

Insert A →

~~Additionally, the OPERABILITY of the Refueling Water Storage Tank as part of the ECCS ensures that sufficient negative reactivity is injected into the core to counteract any positive increase in reactivity caused by RCS system cooldown. RCS cooldown can be caused by inadvertent depressurization, a loss-of-coolant accident, or a steam line rupture.~~

The contained water volume limit includes an allowance for water not usable because of tank discharge line location or other physical characteristics.

The limits on contained water volume and boron concentration of the RWST also ensure a pH value of between ~~8.5~~ 7.8 and 11.0 for the solution recirculated within containment after a LOCA. This pH band minimizes the evolution of iodine and minimizes the effect of chloride and caustic stress corrosion on mechanical systems and components.

INSERT A

The OPERABILITY of the RWST as part of the ECCS ensures that a sufficient supply of borated water is available for injection by the ECCS in the event of either a LOCA, a steamline break or inadvertent RCS depressurization. The limits on RWST minimum volume and boron concentration ensure 1) that sufficient water is available within containment to permit recirculation cooling flow to the core, 2) that the reactor will remain subcritical in the cold condition (68 to 212 degrees-F) following a small break LOCA assuming complete mixing of the RWST, RCS, Spray Additive Tank (SAT), containment spray system piping and ECCS water volumes with all control rods inserted except the most reactive control rod assembly (ARI-1), 3) that the reactor will remain subcritical in the cold condition following a large break LOCA (break flow area $\geq$ 3.0 sq. ft.) assuming complete mixing of the RWST, RCS, ECCS water and other sources of water that may eventually reside in the sump post-LOCA with all control rods assumed to be out (ARO), 4) long term subcriticality following a steamline break assuming ARI-1 and preclude fuel failure.

The maximum allowable value for the RWST boron concentration forms the basis for determining the time (Post-LOCA) at which operator action is required to switch over the ECCS to hot leg recirculation in order to avoid precipitation of the soluble boron.

3/4.6.2.2 SPRAY ADDITIVE SYSTEM

The OPERABILITY of the spray additive system ensures that sufficient NaOH is added to the reactor building spray in the event of a LOCA. The limits on NaOH volume and concentration ensure a pH value of between ~~8.5~~ 7.8 and 11.0 for the solution recirculated within containment after a LOCA. This pH band minimizes the evolution of iodine and minimizes the effect of chloride and caustic stress corrosion on mechanical systems and components. The contained solution volume limit includes an allowance for solution not usable because of tank discharge line location or other physical characteristics. These assumptions are consistent with the iodine removal efficiency assumed in the accident analyses.

3/4.6.2.3 REACTOR BUILDING COOLING SYSTEM

The OPERABILITY of the reactor building cooling system ensures that 1) the reactor building air temperature will be maintained within limits during normal operation, and 2) adequate heat removal capacity is available when operated in conjunction with the reactor building spray systems during post-LOCA conditions.

The reactor building cooling system and the reactor building spray system are redundant to each other in providing post accident cooling of the reactor building atmosphere. As a result of this redundancy in cooling capability, the allowable out of service time requirements for the reactor building cooling system have been appropriately adjusted. However, the allowable out of service time requirements for the reactor building spray system have been maintained consistent with that assigned other inoperable ESF equipment since the reactor building spray system also provides a mechanism for removing iodine from the reactor building atmosphere.

3/4.6.3 PARTICULATE IODINE CLEANUP SYSTEM

The OPERABILITY of the containment filter trains ensures that sufficient iodine removal capability will be available in the event of a LOCA. The reduction in containment iodine inventory reduces the resulting site boundary radiation doses associated with containment leakage. The operation of this system and resultant iodine removal capacity are consistent with the assumptions used in the LOCA analyses.

ATTACHMENT II

NO SIGNIFICANT HAZARDS DETERMINATION

Sections 3.1.2.5, 3.1.2.6, 3.5.1, and 3.5.5 identify allowable boron concentrate limits for the ECCS accumulators and RWST. The proposed changes increase the allowable boron concentrations to the following:

	MIN	MAX
ECCS ACCUMULATORS	2200 -	2500 ppm
RWST	2300 -	2500 ppm

The purpose of these changes is to increase current margin to a post-LOCA shutdown requirement (i.e., the reactor will remain subcritical in the cold condition following a large break LOCA assuming complete mixing of the RWST, RCS and ECCS water and other sources of water that may eventually reside in the sump post-LOCA with all control rods assumed to be out) in order to have increased assurance of conformance for Cycle 4 and future cycles at Virgil C. Summer Nuclear Station.

1. Will operation of the facility in accordance with this proposed change involve a significant increase in the probability or consequences of an accident previously evaluated? NO

   The proposed increases in allowable boron concentrations do not significantly increase the probability or consequences of previously evaluated accidents. A review of the current safety analysis indicate:

   a. The only non-LOCA safety analyses affected are those in which the Safety Injection System (SIS) is actuated. For these accidents no adverse impact will occur, and the conclusions as stated in the FSAR will remain valid. For most accidents, the higher boron concentrations are beneficial since a more rapid negative reactivity insertion will occur.

   b. In the small break LOCA analysis, there is no assumption regarding the concentration of boron in the ECCS water and no credit is taken for the negative reactivity produced by soluble boron. Thus, the FSAR conclusions remain valid with the higher allowable boron concentrations.

   c. Like small breaks, the large break analysis takes no credit for boron in the ECCS water up to the time of peak clad temperature. The FSAR conclusions remain valid.

   d. For maintenance of post-LOCA long term cooling, the higher boron concentrations decrease the maximum allowable time for operator action (i.e., from 24 hours to 11 hours to start hot recirculation and from 24 hours to 18 hours to subsequently alternate hot leg and cold leg recirculation) to prevent boron precipitation. The resulting operator action times, although less, are judged to still be adequate to assure the required actions can be accomplished to maintain post-LOCA long term cooling.

e. The increased boron concentrations and resulting lower post-LOCA containment spray and recirculating core cooling solution pH are acceptable. The design basis for pH sensitive issues (i.e., LOCA radiological consequences, hydrogen generation, and environmental conditions for equipment qualification) are maintained.

Given the above and the fact that conformance to post-LOCA shutdown requirements will be ensured through the normal Reload Safety Analysis Checklist (RSAC) evaluation process, it is concluded that the Technical Specification modifications do not involve a significant increase in the probability or consequence of a previously evaluated accident.

2. Will operation of the facility in accordance with this proposed change create the possibility of a new or different kind of accident from any accident previously evaluated? NO

The creation of a new or different kind of accident from any previously evaluated accident is not considered a possibility. The proposed changes increase existing boron concentration limits within current operational restraints and without compromising the performance or qualification of safety related equipment. Thus, these changes are considered to be adjustments within the Virgil C. Summer design bases and thus do not create the possibility of a new or different kind of accident.

3. Will operation of the facility in accordance with the proposed change involve a significant reduction in a margin of safety? NO

The proposed Technical Specification changes maintain the Final Safety Analysis Report design bases and adequate margins of safety. The higher boron concentrations increase the negative reactivity insertion capability of the ECCS providing an increase in the plants margin of safety. As discussed in item 1.d above, the higher boron concentrations do impact safety by decreasing the allowable operator action times to prevent boron precipitation in the long term following a LOCA. However, the required operator actions can still be easily accomplished within the minimum acceptable time restraints to prevent boron precipitation. Therefore, the proposed increases in the Technical Specification boron concentrations do not result in a significant reduction in margins of safety.

VIRGIL C. SUMMER NUCLEAR STATION
SAFETY EVALUATION
FOR
RWST/ACCUMULATOR BORON CONCENTRATION INCREASE

1.0 INTRODUCTION

The large break Loss-of-Coolant Accident (LOCA) Analysis for the Virgil C. Summer Nuclear Station (VCSNS) takes no credit for control rod insertion. Consequently, to maintain the validity of the analysis, it must be demonstrated (each cycle) that the core can be maintained subcritical via boron addition from the ECCS in the unlikely event of a LOCA $\geqq 3.0$ ft.^{2}. This post-LOCA shutdown requirement has been met for cycles 1-3 at VCSNS. However, evaluations of potential future fuel cycle designs show that conformance is not assured with the present plant design. In order to achieve adequate design flexibility for future cycles, an increase in the accumulator and RWST boron concentration range to 2300 to 2500 ppm for the RWST and 2200 to 2500 ppm for the accumulators is proposed. These changes to the VCSNS Technical Specifications will increase the current margin to the post-LOCA shutdown requirement without compromising safety.

2.0 SCOPE OF EVALUATION

In conjunction with the Westinghouse Electric Corporation, SCE&G has assessed the impact of increasing the RWST and accumulator boron concentration to 2300 to 2500 ppm for the RWST and 2200 to 2500 ppm for the accumulators. This assessment identified the following areas in which the boron concentration increase must be shown to have a favorable or non-detrimental impact on the VCSNS design basis:

1. Non-LOCA Safety Analysis

2. LOCA Analysis (10CFR50.46)
   - Small Breaks
   - Large Breaks
   - Long-Term Core Cooling
   - Boron Precipitation

3. LOCA Related Design Consideration
   - Radiological Consequences
   - Hydrogen Production
   - Equipment Qualifications

Evaluation summaries for each of the above areas are provided in the following section.

3.0 SAFETY EVALUATION

3.1 FSAR Non-LOCA Safety Analysis

The RWST, accumulators and the Safety Injection System (SIS) are subsystems of the Emergency Core Cooling System. Upon actuation of the SIS borated water from the RWST is delivered to the reactor coolant system in order to provide adequate core cooling as well as provide sufficient negative reactivity following steamline break transients to prevent excessive fuel failures. The accumulators are a passive system and provide borated water to the RCS when the system pressure drops below approximately 600 psig.

The only non-LOCA safety analyses in which boron from either the RWST or accumulators is taken credit for, or assumed to be present, are those in which the SIS is actuated. These analyses are:

- Accident Depressurization of the Main Steam System (FSAR Section 15.2.13)
- Inadvertent Operation of the Emergency Core Cooling System During Power Operation (FSAR Section 15.2.14)
- Minor Secondary System Pipe Breaks (FSAR Section 15.3.2)
- Major Rupture of a Main Steam Line (FSAR Section 15.4.2.1)
- Major Rupture of a Main Feedwater Line (FSAR Section 15.4.2.2)
- Rupture of a Control Rod Drive Mechanism Housing (FSAR 15.4.6)

The accumulators are active only in the steamline break analyses.

The effect of the proposed increase in the minimum RWST and accumulator boron concentration on each of the above transients is discussed below.

3.1.1 Accidental Depressurization of the Main Steam System

An accidental depressurization of the main steam system results in a cooldown of the RCS which, in the presence of a negative moderator temperature coefficient, causes a positive reactivity excursion. Borated water from the RWST enters the core following actuation of the SIS on low pressurizer pressure. The negative reactivity provided by the 2000 ppm water from the RWST limits the return to power to an acceptable level so that the minimum DNBR remains above the limiting value. As the transient proceeds and more water from the RWST reaches the RCS, the boron concentration in the RCS gradually increases, ultimately causing the core to become subcritical. If the RWST boron concentration were increased to 2300 ppm more negative reactivity would be available to terminate the return to power sooner and at a reduced peak power level. Thus, the maximum core heat flux reached will be reduced. Additionally, the core would become subcritical earlier in the transient. Thus, the minimum DNBR would be higher than for the case currently analyzed with 2000 ppm in the RWST and the conclusions in the FSAR will remain valid.

3.1.2 Inadvertent Operation of the Emergency Core Cooling System During Power Operation

Spurious actuation of the Emergency Core Cooling System while at power would result in a negative reactivity excursion due to the injected boron from the RWST. The decreasing reactor power causes a drop in the core average temperature and coolant shrinkage. If reactor trip on SIS actuation is assumed not to occur, the reactor will ultimately trip on low pressurizer pressure. DNBR is never below the initial value. If the RWST boron concentration were increased from the current minimum value of 2000 ppm to 2300 ppm the negative reactivity excursion would occur at a faster rate causing a more rapid drop in the core average temperature and coolant shrinkage. The reactor will trip on low pressurizer pressure as before, though at an earlier time in the transient. As before the DNBR will never decrease below the initial value. Thus, the conclusions in the FSAR will remain valid.

3.1.3 Minor Secondary System Pipe Breaks

As discussed in the FSAR this event is bounded by major secondary system pipe ruptures discussed below.

3.1.4 Major Rupture of a Main Steam Line

A major rupture of a main steam line results in a rapid cooldown of the RCS which, in the presence of a negative moderator temperature coefficient, causes a positive reactivity excursion. Borated water from the RWST enters the core following actuation of the SIS on low steam line pressure. The negative reactivity provided by the 2000 ppm water from the RWST limits the return to power to an acceptable level so that the minimum DNBR remains above the limiting value. As the transient proceeds and more water from the RWST reaches the RCS, the boron concentration in the RCS gradually increases, ultimately causing the core to become subcritical. If the RWST boron concentration were increased to 2300 ppm more negative reactivity would be available to terminate the return to power sooner and at a reduced peak power level. Thus, the maximum core heat flux reached will be reduced. Additionally, the core would become subcritical earlier in the transient. Thus, the minimum DNBR would be higher than for the case currently analyzed with 2000 ppm in the RWST. The accumulators provide additional borated water after the core has become subcritical. The additional reactivity provided by the higher accumulator boron concentration would increase shutdown margins. Thus, the conclusion of the FSAR will remain valid for the proposed higher boron concentration increases in the RWST and accumulators.

3.1.5 Major Rupture of a Main Feedwater Line

Following the rupture of a main feedwater line actuation of the SIS may occur. Although boron from the RWST is not required to maintain the reactor in a subcritical condition following a feedwater line break, the cold SIS water serves to reduce the RCS temperatures and pressures. An increase in the minimum RWST boron concentration from 2000 ppm to 2300 ppm will increase the negative reactivity insertion rate without affecting the reduction of the RCS temperatures and pressures. Thus, an increase in the RWST boron concentration to 2300 ppm will have no adverse impact on the feedwater line break analysis and the conclusions in the FSAR will remain valid.

3.1.6 Rupture of a Control Rod Drive Mechanism Housing

Following the ejection of a control rod the rapid nuclear power excursion causes the RCS to experience a large pressure rise due to the energy released into the coolant. The RCS pressure then drops as fluid inventory is lost through the break (a maximum of 2 square inches) in the control rod housing. As the RCS pressure continues to drop actuation of the SIS on low pressurizer pressure will inject borated water from the RWST into the RCS. An increase in the RWST boron concentration from the current minimum of 2000 ppm to 2300 ppm will result in more rapid negative reactivity insertion to the core and no interference with the core cooling capability. Thus, the conclusions in the FSAR remain valid.

3.1.7 Conclusion

An increase in the minimum RWST and accumulator boron concentration to 2300 ppm and 2200 ppm respectively will have no adverse impact upon the non-LOCA accident analyses. The conclusions as stated in the FSAR will remain valid.

3.2 FSAR LOCA Analysis (10CFR50.46)

For the full spectrum of postulated breaks, the ECCS is designed to limit the consequences of an accident to within the acceptance criteria of 10CFR50.46. The analysis takes credit for pumped safety injection from the RWST and passive injection of accumulator water to prevent or mitigate the resulting clad temperature increase. Also, both cold and hot leg recirculation of cooling water from the containment sump to maintain long-term cooling is accounted for. The effect of an increase in the RWST and accumulator boron concentrations to 2300-2500 ppm for the RWST and 2200 to 2500 for the accumulators on these aspects of the LOCA analysis is discussed below.

3.2.1 Small Break LOCA

Small break LOCA analyses for VCSNS assume that the reactor core is brought to a subcritical condition by the trip reactivity of the control rods. There is no assumption regarding the concentration of boron in the ECCS water, and no credit is taken for the negative reactivity produced by soluble boron. Thus, the changes to the RWST and Accumulator Tech-Specs covering boron concentrations do not alter the conclusions of the FSAR small break LOCA analysis.

3.2.2 Large Break LOCA

Large break LOCA analyses for VCSNS do not take credit for the negative reactivity introduced by the soluble boron in the ECCS water in determining reactor power level during the early phases of the hypothetical large break LOCA. The traditional large break LOCA analyses performed by Westinghouse analyze the LOCA transient to a time just beyond the time at which Peak Cladding Temperature is calculated to occur. During this time period the reactor is kept subcritical by the voids present in the core. Thus the changes to the RWST and Accumulator Tech-Specs covering boron concentrations do not alter the conclusions of the FSAR large break LOCA analyses.

3.2.3 <u>Long-Term Cooling - Post LOCA Shutdown</u>

SCE&G's licensing position for satisfying the requirements of 10CFR50.46 Paragraph (b) Item (5) "Long-term cooling" is defined in WCAP-8339 (page 4-22). The commitment is that the reactor remain shutdown by the borated ECCS water. Since credit for the control rods is not taken for large break LOCA, the borated ECCS water provided by the RWST and Accumulators must have a concentration that, when mixed with other sources of water, will result in the reactor core remaining subcritical assuming all control rods out (ARO). Figure 1 shows the effect on the post-LOCA RCS/Sump boron concentration as a result of changing the minimum Tech-Spec boron concentration from 2000 to 2300 for the RWST and from 1900 to 2200 for the Accumulators. The result is an increase of about 247 ppm in the RCS/Sump boron concentration. Confirmation that this proposed increase will provide enough margin to keep the core subcritical for long term cooling requirements will be concluded through the normal RSAC evaluation process.

3.2.4 <u>Long-Term Cooling - Boron Precipitation</u>

An analysis has been performed for VCSNS to determine the maximum boron concentration in the reactor vessel following a hypothetical LOCA. This analysis assumed a proposed maximum boric acid concentration of 2500 ppm in the RWST and accumulators and 2200 ppm in the RCS.

The analysis considers the increase in boric acid concentration in the reactor vessel during the long term cooling phase of a LOCA, assuming a conservatively small effective vessel volume. This volume includes only the free volumes of the reactor core and upper plenum below the bottom of the hot leg nozzles. This assumption conservatively neglects the mixing of boric acid solution with directly connected volumes, such as the reactor vessel lower plenum. The calculation of boric acid concentration in the reactor vessel considers a cold leg break of the reactor coolant system in which steam is generated in the core from decay heat while the boron associated with the boric acid solution is completely separated from the steam and remains in the effective vessel volume.

The results of the analysis show that the maximum allowable boric acid concentration of 23.53 weight percent which is the boric acid solubility limit less 4 weight percent, will not be exceeded in the vessel if hot leg injection is initiated 11 hours after the LOCA inception. Thereafter the operator should alternate between hot and cold leg recirculation every 18 hours. The operator should reference this switchover time against the reactor trip/SI actuation signal. The typical time interval between the accident inception and the reactor trip/SI actuation signal is negligible when compared to the switchover time.

Procedures philosophy assumes that it would be very difficult for the operator to differentiate between break sizes and locations. Therefore one hot leg switchover time is used to cover the complete break spectrum.

3.2.5 Conclusions

The increase in the RWST boron concentration from a range of 2000 to 2100 to a range of 2300 to 2500 ppm and Accumulator boron concentration from a range of 1900 to 2100 to a range of 2200 to 2500 ppm do not have a negative effect on the FSAR LOCA analysis. Current margin to the post-LOCA shutdown requirement is increased and continued conformance will be insured through the normal RSAC evaluation process. The higher concentrations do decrease the allowable time for operator action to initiate hot leg recirculation(24 hours to 11 hours) and to subsequently alternate between hot and cold recirculation (every 24 hours to every 18 hours) to prevent boron precipitation in the long term. The resulting time requirements (11 and 18 hours) are still more than adequate to assure those operator actions can be accomplished. Therefore, the higher boron concentrations do not have a detrimental impact on maintenance of long-term cooling.

3.3 LOCA Related Design Consideration

Increasing the boron concentration in the Refueling Water Storage Tank (RWST) and accumulators decreases the pH of the containment spray and recirculating core cooling solutions. A decrease in pH can decrease the elemental iodine spray removal coefficient and decontamination factor (DF), increase the rate of hydrogen production due to corrosion of zinc (galvanied and zinc based paint) and can increase the potential for chloride induced stress corrosion cracking of stainless steel.

Based on the above considerations, 2500 ppm has been determined to be an acceptable maximum RWST and accumulator boron concentration. Details of the specific evaluations follow.

3.3.1 Radiological Consequences

The minimum calculated spray and sump pH values are sufficient to support the elemental iodine spray removal coefficient and DF assumed in the FSAR LOCA dose analysis. Hence, the radiological consequences will not change as a result of the boron increase, and the FSAR dose analysis remains valid. This conclusion is supported by spray and sump pH calculations.

Spray pH

The minimum calculated spray pH is 9.2 based on a minimum sodium hydroxide flow of 55 gal/min. The minimum pH assumed to maximum elemental iodine removal by sprays is 8.5 (references 1 and 2). The calculated pH exceeds the minimum value and is considered sufficient to support the spray removal coefficient of 12.55 hr-1 assumed in the FSAR (Table 15.4-15).

Sump pH

The calculation of the minimum equilibrium sump solution pH considers the following delivered tank volumes and boron concentrations:

RWST - 467,000 gal, 2500 ppm B
Accumulators (3) - 22,782 gal, 2500 ppm B
RCS (hot zero power, no xenon) - 70,726 gal, 2200 ppm B

The resulting pH is 7.8. This value is sufficient to support a partition coefficient of approximately 3000 which supports the elemental iodine DF of 100 that is assumed in the FSAR dose analysis.

3.3.2 Hydrogen Production

Hydrogen produced by the corrosion of aluminum and zinc is a strong function of solution pH. The corrosion rates incorporated in the FSAR Chapter 15 combustible gas analysis were based on a spray pH of approximately 11, which is consistent with the maximum NaOH (pH approximately 10.7) case shown in FSAR Figure 6.2-51s.

The corrosion data provided in Reference 3 were used to determine the effect on corrosion of reduced spray pH. Figure 5, from the reference, shows maximum zinc corrosion rates at pH 7 and 11 and minimum corrosion at approximately pH 9. Noting that the reduced pH values as well as the FSAR values are within the above range, and that the new values will always be lower than the FSAR values, due to the increased boron concentration, the lower pH corrosion rates will be bounded by the FSAR rates.

Boron concentration effects on zinc corrosion were also investigated. Based on the method of reference 4, a 300 ppm increase in boron concentration, from 2200 to 2500 ppm, resulted in as much as a 6% decrease in corrosion rate, dependent upon temperature and pH.

The aluminum corrosion rates, provided in Figure 6 of Reference 3, decrease monotonically with decreasing pH. hence, aluminum corrosion will decrease with increasing boron concentration.

To summarize, the rates of hydrogen generation due to corrosion of aluminum and zinc, for the increased boron/decreased pH condition, will be less than the rates specified in the FSAR. Hence, the FSAR analysis bounds the reduced pH condition.

3.3.3 Equipment Qualification

The primary concerns of equipment qualification are protection of the stainless steel components of the emergency core cooling system from chloride induced stress corrosion cracking, failures of electrical components required to operate post accident, and failures of containment coatings which could jeopardize the ECCS by flaking or peeling off, clogging the emergency sump and other flow paths, and thus restrict the flow of emergency core cooling water.

Protection of Stainless Steel

To minimize the occurrence of chloride stress corrosion cracking of stainless steel, Westinghouse recommends maintaining the equilibrium sump solution pH above 7.5 (Reference 5). The minimum calculated sump solution pH of 7.8 satisfies this requirement.

Electrical Components

Electrical equipment testing is used to determine the ability of component seals to exclude the containment environment from the interior of the component. To maximize the challenge to the seal materials, high pH sprays in the range of 8 to 11 have traditionally been used.

For all modes of containment spray and ECCS operation, the solution pH with increased boron concentration will always be less than the corresponding pH with reduced boron. Hence, components qualified at higher pH are expected to have a longer post-accident service life in a lower pH (in the caustic range) environment.

Containment Coatings

Coatings are used in the containment to provide corrosion protection for metals and to aid in decontamination of surfaces during normal operation.

Like electrical equipment, coatings are tested with a high pH solution to maximize the potential deterioration of the coating and are expected to show better resistance to lower pH solutions.

4.0 SUMMARY AND CONCLUSIONS

The proposed increase in the RWST and accumulator allowable boron concentration limits to 2300 to 2500 ppm for the RWST and 2200 to 2500 ppm for the accumulators has been assessed from a safety standpoint. Table 1 identifies the safety issues examined, the relevant (upper or lower) boron concentration limit, and conclusions from the safety evaluation. Based on these results, it is concluded that the proposed boron concentration increases will have no adverse impact on the non-LOCA Accident Analysis, the LOCA Analysis or LOCA Related Design Considerations and is thus acceptable for implementation at Virgil C. Summer Nuclear Station beginning with Cycle 4. Confirmation that the boron concentration increases will provide enough margin to meet post-LOCA shutdown requirements will be insured through the normal Westinghouse RSAC evaluation process.

5.0 REFERENCES

1. "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," NUREG-75/087, Section 6.5.2, November, 1975.

2. "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," NUREG-0800, Section 6.5.2, July, 1981.

3. "Corrosion Study for Determining Hydrogen Generation from Aluminum and Zinc During Post-Accident Conditions," WCAP-8776, April, 1976.

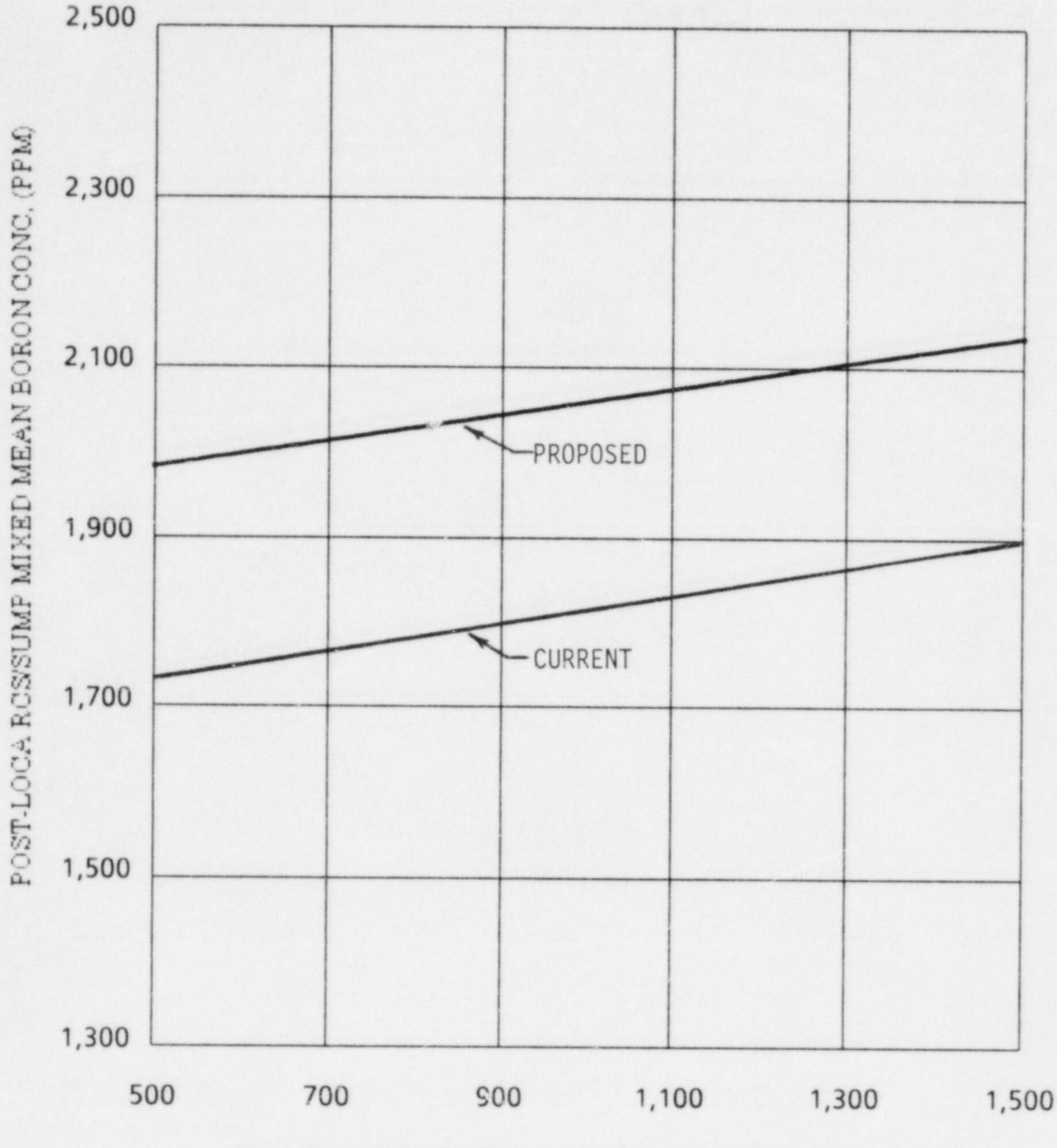
4. "The Relative Importance of Temperature, pH and Boric Acid Concentration of Rates of H2 Production from Galvanized Steel Corrosion," NUREG/CR-2812, November, 1983.

5. "Behavior of Austinitic Stainless Steel in Post Hypothetical Loss of Coolant Environment," WCAP-7798-L, November, 1971.

TABLE 1 SUMMARY OF SAFETY EVALUATION

ITEM	PROPOSED TECH SPEC VALUE	SAFETY ISSUE	CONCLUSION
Boron Cocnentration -UPPER LIMIT-	2500 ppm for both RWST & Accumulator	Post LOCA Boron Precipitation	Operator has adequate time to initiate HL recirculation (11 hours) and to subsequently alternate HL and CL recirculation (every 18 hours) to prevent boron precipitation.
		LOCA Radiological Conseqences	Spray and sump pH changes do not invalidate FSAR assumptions for elemental iodine spray removal coefficient and decontamination factor. Therfore, the FSAR dose analysis remains valid.
		Hydrogen Production	Rates of hydrogen generation due to corrosion of aluminum and zinc, for the increased boron/decreased pH conditions, will be leass than the rates specified in the FSAR. The FSAR analyses remains bounding.
		Equipment Qualification	The increased boron/decreased pH conditions do not invalidate environment conditions assumed for equipment qualification.
Boron Concentration -LOWER LIMIT-	2300 ppm for RWST & 2200 ppm for Accumulators	Non-LOCA Safety Analysis	No adverse impact. The conclusions as stated in the FSAR remain valid.
		Small Break LOCA Analysis	Analysis takes no credit for boron in ECCS water and is thus not affected.
		Large Break LOCA Analysis	Up to time of peak clad temperature, analyses takes no credit for boron in the ECCS water and are thus not affected.
		Post LOCA Shutdown (≥ 3.0 ft.2)	Confirmation that core is kept subcritical with all rods out will be ensured through the RSAC evaluation process.

FIGURE 1



V. C. SUMMER UNIT 1 CURRENT LIMITS FOR CYCLE 4 POST-LOCA SUMP/RCS MIXED MEAN BORON CONCENTRATION VS. PRE-TRIP RCS BORON CONCENTRATION AT HFP-PK XE-ARO