Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

August 21, 2006
LIC-06-0088

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, D.C. 20555

References:
1. Docket No. 50-285
2. Letter from OPPD (H. J. Faulhaber) to NRC (Document Control Desk), "Revised Request for an Extension to the Completion Date for Corrective Actions Taken in Response to Generic Letter 2004-02," dated June 9, 2005 (LIC-06-0067)
3. Letter from NRC (C. Haney) to OPPD (R. T. Ridenoure), "Fort Calhoun Station, Unit No. 1 - Generic Letter 2004-02, Extension Request Approval (TAC No. MD2323)" dated August 11, 2006 (NRC-06-0103)

SUBJECT: Fort Calhoun Station, Unit No. 1 License Amendment Request (LAR) "Change of Containment Building Sump Buffering Agent from Trisodium Phosphate to Sodium Tetraborate"

Pursuant to 10 CFR 50.90, Omaha Public Power District (OPPD) hereby requests the following amendment to the Fort Calhoun Station, Unit No. 1 (FCS) Technical Specifications (TS):

1. Revise existing TS Section 2.3(4), "Trisodium Phosphate (TSP)," to change the reactor containment building sump buffering agent from trisodium phosphate (TSP) to sodium tetraborate (NaTB). OPPD is also proposing to change the TS section title to "Containment Sump Buffering Agent Specification and Volume Requirement."
2. The surveillance requirement of TS 3.6(2)d is revised to require a volume of NaTB that is within the area of acceptable operation of Figure 2-3.

Corresponding Technical Specifications Basis changes are also requested.

The buffering agent change supported by this LAR will help reduce the potential for containment sump blockage following a loss-of-coolant accident (LOCA), as described in OPPD's revised Generic Letter 2004-02 extension request (Reference 2), approved by the NRC in Reference 3. Replacement of TSP with NaTB will prevent the potential adverse chemical interaction between components of insulating material (i.e., calcium silicate) used in containment and TSP.

Based on discussions with the NRC staff, OPPD requests that approval of the requested TS changes be limited to one operating cycle (Cycle 24), i.e., until the spring 2008 refueling outage. In 2007, OPPD plans to submit another LAR supporting operation during subsequent cycles.

Attachment 1 contains the OPPD evaluation of the proposed TS change. Attachment 2 provides the mark-up of the TS pages reflecting the requested changes. Attachment 3 provides the proposed Technical Specifications. Attachment 4 contains the summary report of testing of alternative emergency core coolant system buffering agents for FCS.

OPPD respectfully requests NRC approval by October 30, 2006. OPPD proposes to implement the proposed Amendment prior to plant startup from the 2006 Refueling Outage scheduled to begin September 9, 2006. No commitments are made to the NRC in this letter.

If you have additional questions, or require further information, please contact Mr. Thomas C. Matthews at (402) 533-6938.

I declare under penalty of perjury that the forgoing is true and correct. (Executed on August 21, 2006.)

Sincerely,

J. A. Reinhart
Site Director
Fort Calhoun Station

JAR/mle

Attachments:

1. Evaluation for Amendment of FCS Facility Operating License No. DPR-40
2. Requested Changes to Technical Specifications for FCS Facility Operating License No. DPR-40
3. Proposed Technical Specifications for FCS Facility Operating License No. DPR-40
4. LTR-CDME-06-115, Rev. 0, "Summary Report for Testing of Alternative Emergency Core Coolant System Buffering Agents for Fort Calhoun Station," August 15, 2006

c: Director of Consumer Health Services, Department of Regulation and Licensure, Nebraska Health and Human Services, State of Nebraska

Evaluation for Amendment of FCS Facility Operating License No. DPR-40

Evaluation for Amendment of FCS
Facility Operating License No. DPR-40

1.0 INTRODUCTION

The Omaha Public Power District (OPPD) is requesting to amend Operating License DPR-40 for Fort Calhoun Station, Unit No. 1 (FCS) by revising Technical Specifications (TSs) 2.3(4), "Trisodium Phosphate (TSP)" and 3.6(2)d, "Safety Injection and Containment Cooling Systems Tests" and their associated Basis sections. Based on discussions with the Nuclear Regulatory Commission (NRC) staff, OPPD requests that approval of the requested TS changes be limited to one operating cycle (i.e., until the spring 2008 refueling outage). In 2007, OPPD plans to submit another License Amendment Request (LAR) supporting operation during subsequent cycles.

FCS Technical Specification 2.3(4) currently requires the use of trisodium phosphate (TSP) as the buffering agent in the containment sump. OPPD proposes to change the title of the TS Section to the more general "Containment Sump Buffering Agent Specification and Volume Requirement" and to replace TSP with hydrated sodium tetraborate (NaTB) within TS 2.3(4) and the Basis for TS 2.3. The purpose of this change is to minimize the potential for exacerbating sump screen blockage concerns under post loss-of-coolant accident (LOCA) conditions due to a potential adverse chemical interaction between TSP and certain insulation materials used in containment. The Basis of TS 2.3 is likewise revised to indicate the use of NaTB rather than TSP. These changes will maintain the intent of TS 2.3(4) and its Basis as described in NUREG-1432, Rev. 3, "Standard Technical Specifications Combustion Engineering Plants." NUREG-1432, Rev. 3 specifies the use of TSP to ensure that iodine, which may be dissolved in the recirculated reactor cooling water following a LOCA, remains in solution. TSP also helps inhibit stress corrosion cracking (SCC) of austenitic stainless steel components in containment during the recirculation phase following an accident. NaTB serves this same function, maintaining the intent of the TS, albeit through the use of a different buffering agent. The use of NaTB at FCS was selected following a rigorous evaluation (Reference 1).

Currently, TS 2.3(4) requires a TSP volume that is a function of Reactor Coolant System (RCS) critical boron concentration (CBC) over an operating cycle as shown in TS Figure 2-3. Allowing the required buffering agent volume to trend downward during the operating cycle with decreasing hot zero power (HZP) critical boron concentration (CBC) enables the containment sump to achieve a pH $\geq$ 7.0. This ensures that all borated water and acid sources are neutralized. This option also provides adequate margin to compensate for the effect of buffering agent densification.

The proposed revision, in addition to replacing TSP with NaTB, modifies Figure 2-3, which shows the minimum required volume of buffering agent versus HZP CBC over the operating cycle, so that it is consistent with the replacement buffering agent. The buffering agent volume requirements outlined in Figure 2-3 bound expected HZP CBC for any operating cycle. Based on historical data, the beginning of cycle HZP CBC is

bounded by 1800 ppm and the end of cycle (EOC) is bounded by 550 ppm. Thus, these points were chosen to generate the curve. The end of cycle HZP CBC could be less than 550 ppm so the curve is extended as a horizontal line at this point. Therefore, the minimum required volume of buffering agent does not decrease below that required at a HZP CBC level of 550 ppm. It is proposed to revise TS 2.3(4) and TS 3.6(2)d to require compliance with Figure 2-3 during Operating Modes 1 and 2. Corresponding Basis changes are also proposed.

2.0 DESCRIPTION OF PROPOSED AMENDMENT

The proposed amendment replaces the containment sump buffering agent specification from TSP to NaTB in TSs 2.3(4) and 3.6, and revises their respective Bases to require NaTB. These changes make TS 2.3(4) and its Basis consistent with the intent of NUREG-1432, Rev. 3, "Standard Technical Specifications Combustion Engineering Plants" as discussed above. TS 2.3(4) also requires adherence to Figure 2-3 that specifies the minimum required volume of buffering agent versus HZP CBC over the operating cycle. The buffering agent volume requirements outlined in Figure 2-3 bound expected HZP CBC for any operating cycle. Based on historical data, the beginning of cycle HZP CBC is bounded by 1800 ppm and EOC is bounded by 550 ppm. Thus, these points were chosen to generate the curve.

The end of cycle HZP CBC could be less than 550 ppm so the curve is extended as a horizontal line at this point so that the buffering agent volume required by TS 2.3(4) cannot be less than the amount required at a HZP CBC value of 550 ppm. The surveillance requirement of TS 3.6(2)d verifies that the volume of buffering agent is in compliance with Figure 2-3. Corresponding Basis changes to TS 3.6 are also proposed. The proposed changes are described below. A markup and clean copy of the TS pages are included in Attachments 2 and 3, respectively.

The title of TS 2.3(4) "Trisodium Phosphate (TSP)," is revised to a more general "Containment Sump Buffering Agent Specification and Volume Requirement."

TS 2.3(4) is revised to read: "During Operating Modes 1 and 2, the containment sump buffering agent baskets shall contain a volume of hydrated sodium tetraborate (NaTB) that is within the area of acceptable operation shown in Figure 2-3."

Likewise, the Basis of TS 2.3 is revised to replace TSP with NaTB. The Basis of TS 2.3 is revised to incorporate the intent of information from the Basis of Limiting Condition for Operation (LCO) 3.5.5 of NUREG-1432, Rev. 3. Because the highest hydrated form NaTB is being used, it will not pick up additional waters of hydration during storage in areas with elevated humidity (Reference 1).

Figure 2-3 is modified in proposed TS 2.3 to show the areas of acceptable and unacceptable operation for the volume of NaTB required over the operating cycle versus HZP CBC.

TS 3.6(2)d is revised to reflect the change to a new buffering agent (NaTB) including the use of a revised Figure 2-3. To correct an error in the NRC Authority File of the FCS License, an extraneous "i" is removed from TS 3.6(2)d(i). This is an administrative correction.

The Basis of TS 3.6 is revised to provide additional detail concerning surveillance of the buffering agent volume. Due to the change in and the modified volume of buffering agent required by TS 2.3(4), the description of pH testing of buffering agent samples in the Basis of TS 3.6 is also being revised.

3.0 BACKGROUND

Under LOCA conditions, buffering agents must be added to the Emergency Core Cooling System (ECCS) to increase the coolant pH to greater than 7.0. Buffering agent addition is mainly required to reduce release of iodine fission products from the coolant to the containment atmosphere as iodine gas. Thus, pH control is primarily an offsite dose control measure. Increasing the coolant pH also reduces the corrosion rates of most materials in the containment sump, most notably metal structural members and components. Traditionally, TSP is used as the buffering agent at many plants, including FCS. The buffering agent is stored in baskets that become submerged within the containment sump pool (as the post LOCA water level rises) and release the buffering agent by dissolution.

TSP was initially selected as a post LOCA buffering agent because of its many favorable characteristics. In particular, it dissolves rapidly and the quantity needed to increase the coolant pH above 7.0 is reasonable. It also has corrosion inhibitor properties beyond its ability to moderate pH. For example, steel corrosion is inhibited through the formation of iron phosphate conversion coatings. In the hydrated form, it has a good storage life, is inexpensive and is readily available.

Under LOCA conditions, calcium could be released into the coolant due to dissolution of calcium-bearing materials (Reference 2). Of particular concern at FCS is the potential release of calcium from calcium silicate insulation. TSP could react with dissolved calcium to form insoluble calcium phosphates (Reference 3). The resultant calcium phosphate precipitates may collect on fibrous beds and exacerbate flow restrictions within the ECCS at the containment sump screen. Recent tests performed by Argonne National Laboratory (ANL) have demonstrated the reaction between TSP and calcium silicate insulation and the resulting impact on head loss (Reference 3). The Nuclear

Regulatory Commission (NRC) informed the industry in Information Notices 2005-26 and 2005-26, Supplement 1 of the potential for calcium phosphate precipitation leading to head loss.

A Pressurized Water Reactor Owners Group (PWROG) task (Reference 4) investigated the ability to reduce or eliminate the risk of calcium phosphate precipitant formation simply by replacing TSP with another chemical that does not react with the materials in containment to form precipitants. The program tested alternative buffering agents to determine the efficacy of these materials to replace TSP. The results of the PWROG activity were reported in WCAP-16596-NP, "Evaluation of Alternative Emergency Core Cooling System Buffering Agents" (Reference 5). The results of the candidate buffer testing were used to determine the appropriate replacement for TSP at Fort Calhoun Station (Reference 1). The buffering agent selected to replace TSP at FCS is sodium tetraborate (NaTB).

System Description

After a LOCA, the components of the core cooling and containment spray systems will be exposed to high temperature borated water. Prolonged exposure to the core cooling water combined with stresses imposed on the components can cause stress corrosion cracking (SCC). SCC is a function of stress, oxygen and chloride concentrations, pH, temperature, and alloy composition of the components. High temperatures and low pH, which would be present after a LOCA, tend to promote SCC, which in turn can lead to the failure of necessary safety systems or components. The buffering agent is stored in wire mesh dissolving baskets located in the containment on the basement level near the outer wall. The baskets have a maximum capacity of 131.9 ft^3.

As it fills the containment sump, the safety injection water dissolves the buffering agent, which resides in baskets on the sump floor. Mixing is achieved as the solution is continuously recirculated. Control of pH is critical for the compatibility of the recirculation water with equipment located in containment. Post LOCA containment sump pH values substantially greater than 7.0 may affect the EEQ and hydrogen generation design basis and thus maximum sump pH is limited (Reference 6). This prevents significant amounts of iodine, released from failed fuel and dissolved in the recirculation water, from converting to a volatile form and evolving into the containment atmosphere. High levels of airborne iodine in containment could increase the radiological consequences of the accident. A pH $\geq$ 7.0 is also necessary to prevent SCC of austenitic stainless steel components located in containment, which could increase the probability of component failure.

Radiation levels in containment following a LOCA may cause the generation of hydrochloric and nitric acids from radiolysis of cable insulation and air. The buffering agent mixed in the recirculation water neutralizes these acids as well.

USAR References

USAR Section 4.4.3 "Prevention of Stress Corrosion Cracking" (Reference 6), specifies (via Figure 4.4-1) that the containment sump buffering agent baskets contain a required volume of buffering agent versus Reactor Coolant System Hot Zero Power (HZP), Critical Boron Concentration (CBC) over the operating cycle. USAR Section 4.6 "Specific References" lists the calculations and engineering analyses that support plant operation with the quantity of buffering agent being used.

USAR Section 14.15.6 “Long Term Core Cooling (LTCC) Considerations (ECCS)” (Reference 7), discusses the timing associated with simultaneous hot and cold leg injection for both large and small break LOCAs and the associated Emergency Operating Procedures (EOPs). The simultaneous hot and cold leg injection timing is influenced by the boron precipitation rate associated with the particular buffering agent being used. In this regard, the particular buffering agent employed can impact the hot and cold leg injection timing, also referred to as the Hot Leg Switchover (HLSO) time, by affecting the boric acid solubility limits. The HLSO time is determined as part of the Long Term Core Cooling (LTCC) analysis required by 10 CFR 50.46. This analysis and the HLSO time assure that boron precipitation will not inhibit core cooling.

An evaluation of the FCS hot leg switchover (HLSO) time calculation was performed in response to generic concerns identified by the NRC (Reference 8). The evaluation concluded that the existing 8.5 hour HLSO time remained conservative with credit for the boric acid solubility increase due to the TSP containment sump buffering agent. An evaluation of the effect of the replacement buffering agent, NaTB, on boric acid solubility indicated it was less effective than TSP at raising the boric acid solubility limit. Consequently, a new more conservative HLSO time has been calculated which addresses the generic issues raised by the NRC. This analysis addressed the concerns outlined in Reference 8 by:

- Using the required Appendix K decay heat.
- Calculating a time varying core effective mixing volume that included consideration of core voiding, 50% mixing in the lower plenum and system flow resistance with locked reactor coolant pump rotors on core mixture level, as recently applied for extended power uprate submittals (References 9 and 10).
- Implementing a more conservative 5.5 hour HLSO time that ensures hot leg recirculation flow will be initiated by 6 hours, at which time the core remains

below the boric acid solubility limit without the need to credit the effect of the containment sump buffering agent on boric acid solubility.

New, higher recirculation flow requirements of 147 gpm for cold leg flow and 159 gpm for hot leg flow have been established based on the higher core steaming rate at 5.5 hours. For small break LOCAs, where system pressures remain above 120 psig (135 psia), boric acid cannot precipitate because the solution saturation temperature is above the limit at which boric acid can come out of solution. The revised HLSO procedure will ensure that recirculation flow is initiated at or below 120 psig anytime after 5.5 hours following the LOCA initiation. Therefore, sufficient flushing flow will be established before the core mixing volume reaches the boric acid solution precipitation limit in the event of either small or large break LOCA without reducing core cooling effectiveness. Since the HLSO time will be reduced and the recirculation flow requirements increased, the OPPD Emergency Operating Procedures (EOPs) are being updated to reflect these new requirements.

USAR Section 14.15.8 "Radiological Consequences of a LOCA" (Reference 11), discusses post LOCA chemical interaction considerations that influence the determination of the quantity of buffering agent required.

Existing Operating Condition

Following the initiation of containment spray, boric acid solution with a pH of approximately 5 is sprayed into the containment. This spray comes in contact with most surfaces in the containment including the equipment required for post LOCA. To prevent chloride stress corrosion cracking of certain metals during operation of the ECCS, the spray water pH is raised with a hydrated form of TSP in the range of 45 to 57% moisture content, at a minimum manufactured density of 53.0 lbm/ft^3. A hydrated form is used because of the high humidity in the containment building during normal operation; since the TSP is hydrated, it is less likely to absorb large amounts of water from the humid atmosphere and undergoes less physical and chemical change than the anhydrous form of TSP. The TSP is stored in wire mesh baskets located on the containment sump floor near the outer wall. The safety injection water dissolves the chemical as it fills the containment sump. Mixing is achieved as the solution is continuously recirculated.

As noted above, USAR Figure 4.4-1 shows the minimum required volume of TSP versus RCS HZP, CBC over the operating cycle. The TSP volume requirements outlined in Figure 4.4-1 bound expected HZP CBC for any operating cycle. Based on historical data, the beginning of cycle HZP CBC is bounded by 1800 ppm and the end of cycle (EOC) is bounded by 550 ppm. Thus, these points were chosen to generate the curve. The EOC HZP CBC could be less than 550 ppm so the curve is extended as a horizontal line at this

point. Therefore, the minimum required volume of TSP does not decrease below that required at a HZP CBC level of 550 ppm.

USAR Section 14.15.6 discusses the post LOCA Long Term Core Cooling (LTCC) ECCS performance evaluation for FCS that demonstrates conformance with Criterion 5 of 10 CFR 50.46(b). Procedures control utilizing the ECCS to remove decay heat and maintain core temperatures at acceptably low values for an extended period of time as required by the long-lived radioactive isotopes remaining in the core. LTCC is initiated when the core is reflooded after a LOCA and is continued until the plant is secured. In satisfying this objective, the post LOCA LTCC requirements, as contained in the EOPs, make provisions for maintaining core cooling and boric acid flushing by simultaneous hot and cold leg injection, or for initiating cooldown of the RCS if the break is sufficiently small with natural circulation present, such that success of such operation is assured. If shutdown cooling has not been established, then simultaneous hot and cold leg injection, as discussed previously, is established, within a predetermined timing window (i.e., the HLSO time), after the start of the LOCA in accordance with the EOPs.

USAR Section 14.15.8 discusses the radiological consequences of a LOCA, including the function of the buffering agent used to maintain the sump pH ≥ 7.0. Long term production of acids (HCl and HNO_3) by irradiation is included in determining the required quantity of buffering agent required. Long term retention of iodine in sump liquids is strongly dependent on the sump pH.

Proposed Operating Condition

The proposed operating condition is analogous to the existing operating condition described above except that NaTB replaces TSP and the associated numeric values of affected parameters are adjusted as described below.

Following the initiation of containment spray, boric acid solution with a pH of approximately 5 is sprayed into the containment. This spray comes in contact with most surfaces in the containment including the equipment required for post LOCA. To prevent chloride stress corrosion cracking of certain metals during operation of the ECCS, the spray water pH is raised with NaTB, at a minimum manufactured density of 59.3 lbm/ft^3. A hydrated form is used because of the high humidity in the containment building during normal operation; since the NaTB is hydrated, it is less likely to absorb large amounts of water from the humid atmosphere and undergoes less physical and chemical change. The NaTB is stored in wire mesh baskets located on the containment sump floor level near the outer wall. The safety injection water dissolves the chemical as it fills the containment sump. Mixing is achieved as the solution is continuously recirculated.

USAR Figure 4.4-1 shows the minimum required volume of NaTB versus RCS HZP, CBC over the operating cycle. The volume requirements outlined in Figure 4.4-1 bound expected HZP CBC for any operating cycle. Based on historical data, the beginning of cycle HZP CBC is bounded by 1800 ppm and the EOC is bounded by 550 ppm. Thus, these points were chosen to generate the curve. The EOC HZP CBC could be less than 550 ppm so the curve is extended as a horizontal line at this point. Thus, the minimum required volume does not decrease below that required at a HZP CBC level of 550 ppm.

USAR Section 14.15.6 discusses the post LOCA Long Term Core Cooling (LTCC) ECCS performance evaluation for FCS that demonstrates conformance with Criterion 5 of 10 CFR 50.46(b). Procedures control utilizing the ECCS to remove decay heat and maintain core temperatures at acceptably low values for an extended period of time as required to remove decay heat produced by the long-lived radioactive isotopes remaining in the core. LTCC is initiated when the core is reflooded after a LOCA and is continued until the plant is secured. In satisfying this objective, the post LOCA LTCC requirements, as contained in the EOPs, make provisions for maintaining core cooling and boric acid flushing by simultaneous hot and cold leg injection, or for initiating cooldown of the RCS if the break is sufficiently small with natural circulation present, such that success of such operation is assured. If shutdown cooling has not been established, then simultaneous hot and cold leg injection, as discussed previously, is established, within a predetermined timing window (i.e., the HLSO time), after the start of the LOCA in accordance with the EOPs.

USAR Section 14.15.8 discusses the radiological consequences of a LOCA, including the function of the buffering agent used to maintain the sump pH ≥ 7.0. Long term production of acids (HCl and HNO_3) by irradiation is included in determining the required quantity of buffering agent required. Long term retention of iodine in sump liquids is strongly dependent on the sump pH.

4.0 REGULATORY REQUIREMENTS & GUIDANCE

The changes to TS 2.3(4) and its associated Basis section are consistent with the applicable regulatory requirement in NUREG 0800, Section 6.5.2, "Containment Spray as a Fission Product Cleanup System." Subsection 11.1.g specifies that the pH of all solutions in the containment sump and all additives for reactivity control, fission product removal, or other purposes (boric acid) should be maintained at a level high enough to assure that significant long-term iodine re-evolution does not occur. Long-term iodine retention may be assumed only when the equilibrium sump solution pH, after mixing and dilution with primary coolant and ECCS injection sources (Safety Injection Refueling Water Tank, Safety Injection Tanks, and Boric Acid Storage Tanks), is above 7.0.

Reference 1 conservatively assumes that all borated water sources are at their maximum volume and maximum administrative limit of boric acid concentration in calculating the volume of NaTB required to achieve recirculation water pH $\geq$ 7.0.

No other regulatory requirements or regulatory guidance were identified to be applicable to these TS changes.

5.0 TECHNICAL ANALYSIS

Design Basis

The proposed change to TS 2.3(4) and its Basis section, which replaces the use of TSP with NaTB, maintains consistency with the intent of NUREG-1432, Rev. 3. The Basis of LCO 3.5.5 of NUREG-1432, Rev. 3 specifies the use of the hydrated form of TSP (45 - 57% moisture) because of high humidity in the containment building during normal operation. However, because the use of TSP has been shown to potentially exacerbate post LOCA sump screen blockage due to a potential adverse chemical interaction with certain insulation materials used in containment, OPPD decided to replace the buffering agent chemical employed. Therefore, to preclude the potential for a possible adverse TSP/insulation interaction, OPPD is proposing to replace the TSP with NaTB which has essentially the same buffering agent characteristics as TSP but without the potential adverse consequences.

TS 2.3(4) is also revised to replace the volume of TSP required for compliance with Figure 2-3 with a revised figure based on the use of NaTB. Figure 2-3 shows the minimum required volume of buffering agent as HZP CBC decreases over the operating cycle. Compliance with the revised Figure 2-3 will ensure that containment sump pH is $\geq$ 7.0.

The changes to the surveillance requirements specified in TS 3.6(2)d and the Basis of TS 3.6 will verify the volume of NaTB in accordance with Figure 2-3 and verify the ability of the NaTB to adjust pH to within the desired range. OPPD is replacing the FCS steam generators, pressurizer, and reactor vessel head during the 2006 Refueling Outage. The revised surveillance requirements account for the larger post-LOCA sump water volume that will result.

The proposed amendment meets regulatory and FCS design basis requirements. Throughout the operating cycle, the amendment requires a volume of NaTB sufficient to neutralize all sources of borated water and acids formed from post LOCA degradation of electrical cable jackets and radiolysis of air.

This amendment credits the trend of the RCS HZP CBC to decrease with core burnup over the operating cycle in calculating the minimum required buffering agent volume.

OPPD's evaluation (Reference 1) of a replacement buffering agent determined that NaTB is an acceptable alternative to TSP for use as the ECCS buffering agent at FCS. Use of NaTB could result in a significant reduction in precipitate formation with no adverse side effects as demonstrated by the NRC Integrated Chemical Effects Tests (ICET) with TSP (Reference 3) and NaTB (Reference 14) and the results of the PWROG Chemical Effects (Reference 2) and Alternate Buffer testing (Reference 5). Additionally:

- NaTB provides a comparable buffering capacity to TSP with a comparable quantity of buffering agent, so that the existing buffer delivery scheme can be utilized;
- No new types of precipitates are formed in the target pH range of 7.0 to 8.0, which is within the range of FCS pH control;
- Corrosion to steel structural materials is comparable to that expected with TSP. Corrosion to submerged aluminum in NaTB is higher than in TSP; however, the overall effect of the increased corrosion in NaTB is not significant since dissolved silicate from the insulation materials may serve to inhibit the corrosion of submerged aluminum (Reference 5);
- An evaluation (Reference 5) of the effect of NaTB on boric acid solubility indicated it was less effective than TSP at raising the boric acid solubility limit. Therefore, a new more conservative HLSO time has been calculated for FCS;
- NaTB has been evaluated for other potential chemical effects as part of the PWROG Program (Reference 5) and the ICET program (References 14 and 15) and was found to be acceptable;
- NaTB is already in use at ice condenser plants and has a long and acceptable track record, and;
- Use of NaTB will provide additional dissolved boron for reactivity control.
- In post-accident containment conditions, the dissolution characteristics of NaTB are equivalent to TSP.

OPPD's engineering evaluation determined that compliance with Figure 2-3 (based on use of NaTB) will continue to provide a neutral or very slightly basic pH in the containment sump post LOCA. While the end of cycle HZP CBC could be somewhat less than 550 ppm, the allowable volume of NaTB is not reduced below that required at 550 ppm as indicated by the horizontal line on Figure 2-3.

Risk Information

The scope, level of detail, and technical methods of the calculations and the associated engineering evaluation, conducted to justify the proposed TS change, are based on the as-built and as operated and maintained plant, and reflect the operating experience at FCS in conjunction with the results of the PWROG Buffering Agent Replacement Program (References 4 and 5).

Assumptions, inputs and conclusions in the calculations and the associated engineering evaluation were reviewed and independently verified. A risk-informed approach with the use of probabilistic risk assessment (PRA) or sensitivity study was not considered.

Reference 1 establishes the required NaTB volume needed to raise containment sump pH ≥ 7.0 post LOCA for specified containment sump boric acid concentrations.

6.0 REGULATORY ANALYSIS

The technical evaluation and risk information provided in Section 5.0 satisfies applicable regulatory requirements and guidance concerning the type and volume of NaTB required in the containment sump to ensure post LOCA recirculation water pH ≥ 7.0. OPPD will verify the NaTB volume requirement for the applicable operating cycle based on the HZP CBC cycle limits as part of its core reload analysis process (Reference 16).

The proposed changes are limited in scope to the type and volume of NaTB required when FCS is in Operating Modes 1 and 2 during the operating cycle. As such, OPPD must continue to perform all other currently approved buffering agent verification requirements. These requirements are performed on a refueling frequency and include:

1. Visually determining that the volume of buffering agent required by Figure 2-3 is contained in the baskets and,
2. Performing a chemistry analysis to ensure the solubility and buffering ability of the buffering agent (NaTB) after exposure to the containment environment.

In conclusion, based on the considerations discussed above:

(1) There is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner,

(2) Such activities will be conducted in compliance with the Commission's regulations, and

(3) The issuance of the amendment will not be inimical to the common defense and security of the health and safety of the public.

7.0 NO SIGNIFICANT HAZARDS CONSIDERATION (NSHC)

OPPD has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of Amendment," as discussed below:

1. *Does the proposed change involve a significant increase in the probability or consequences of an accident previously evaluated?*

   Response: No

   There are no changes to the design or operation of the plant that could affect system, component, or accident functions as a result of replacing trisodium phosphate (TSP) with sodium tetraborate (NaTB). Similarly, there are no changes to the design or operation of the plant affecting system, component or accident functions as a result of revising the volume of buffering agent required during Operating Modes 1 and 2 with an amount dependent upon hot zero power (HZP) critical boron concentration (CBC) to make it consistent with the use of NaTB.

   All systems and components function as designed and the performance requirements have been evaluated and found to be acceptable. NaTB will maintain pH $\geq$ 7.0 in the recirculation water following a loss-of-coolant accident (LOCA). This function is maintained with the proposed change. Allowing the required volume of NaTB to decrease over the operating cycle (as a result of densification) as HZP CBC decreases still ensures that the pH of the containment sump is $\geq$ 7.0.

   Further, replacing TSP with NaTB will not increase the probability or consequences of an accident previously evaluated. Other than the Long Term Core Cooling evaluation that establishes the Hot Leg Switchover (HLSO) time, no other safety analysis methodology (LOCA or non-LOCA) specifically models the containment sump buffering agent. As a result, the consequences of any accident (other than determination of the HLSO time) are unaffected by the proposed change to the containment sump buffering agent. The analysis to determine the HLSO time specifically addressed the use of NaTB to assure it would preclude boron precipitation in the core and, therefore, preclude any increase in the consequences of a LOCA.

Analysis demonstrates that a NaTB buffering agent ensures the post LOCA containment sump mixture will have a pH $\geq$ 7.0. Replacing TSP with NaTB, which achieves the same pH buffering requirements, will not increase the probability of a LOCA.

Therefore, the proposed change does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. *Does the proposed change create the possibility of a new or different kind of accident from any accident previously evaluated?*

Response: No

No new accident scenarios, failure mechanisms, or single failures are introduced as a result of the proposed change. All structures, systems, and components (SSCs) previously required for mitigation of an event remain capable of fulfilling their intended design function with this change to the Technical Specifications (TS). The proposed change has no adverse effects on any safety-related system or component and does not challenge the performance or integrity of any safety related system. The proposed change has evaluated the replacement buffering agent and no new accident scenarios or single failures are introduced.

Therefore, the proposed change does not create the possibility of a new or different kind of accident from any previously evaluated.

3. *Does the proposed change involve a significant reduction in a margin of safety?*

Response: No

Changing the containment sump buffering agent requirement from TSP to NaTB and revising the required volume of NaTB to decrease (as a result of densification) as HZP CBC decreases still ensures containment sump pH $\geq$ 7.0. NaTB will maintain pH $\geq$ 7.0 in the recirculation water following a LOCA. Therefore, this change does not involve a significant reduction in the margin of safety. Evaluations were made that indicate that the margin for pH control is not altered by the proposed changes. A NaTB volume that is dependent on HZP CBC has been evaluated with respect to neutralization of all borated water and acid sources. These evaluations concluded that there would be no impact on pH control, and hence no reduction in the margin of safety related to post LOCA conditions.

Although NaTB is less effective than TSP at raising the boric acid solubility limit, implementation of a more conservative HLSO time and higher recirculation flow requirements for the hot and cold leg recirculation flows ensures that the margin of safety to preclude boron precipitation, and ultimately assurance of core cooling ability, is not compromised.

Therefore, the proposed change does not involve a significant reduction in a margin of safety.

Conclusion:

Operation of FCS in accordance with the proposed amendment will not result in a significant increase in the probability or consequences of any accident previously analyzed; will not result in a new or different kind of accident previously analyzed; and does not result in a significant reduction in a margin of safety.

Based on the above, OPPD concludes that the proposed amendment to replace the containment sump buffering agent requirement for the use of TSP with NaTB and modification of the required volume of NaTB with a volume dependent upon HZP CBC as shown in Figure 2-3 presents no significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

8.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. The design function of the buffering agent storage baskets located in containment does not change. However, OPPD will change its current practice of filling the baskets with active TSP and instead utilize NaTB as the buffering agent. NaTB is approved for use at PWRs utilizing an ice condenser containment building. Although the method for introducing NaTB to the post-accident containment sump pool differs from that at ice condenser plants (dissolving versus released from melting ice), environmental considerations are not significantly different. Both systems are passive in nature releasing the buffering agent only in the event of a high energy line break inside containment. As reported in Reference 5, in the initial test of environmental stability, buffer samples were exposed to a simulated containment environment. After 30 days, clumping was observed in both TSP and NaTB, but both buffers readily dissolved in hot water. On the basis of these results, the stability of NaTB in the containment environment can be considered comparable to or slightly better than TSP. The stability of NaTB to radiation exposure

has been demonstrated to be good on the basis that NaTB has been used for many years in ice condenser plants.

The proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore pursuant to 10 CFR 51.22(b), no environmental assessment need be prepared in connection with the proposed amendment.

9.0 PRECEDENCE

NaTB is already in use at ice condenser plants (Reference 12) and has a long and acceptable track record. Utilization of NaTB in place of TSP as a buffering agent at FCS serves an analogous function to its use in ice condenser plants, albeit via a different delivery mechanism (dissolution of granular NaTB versus melting NaTB ice).

10.0 REFERENCES

1. LTR-CDME-06-115, Rev. 0, "Summary Report for Testing of Alternative Emergency Core Coolant System Buffering Agents for Fort Calhoun Station," August 15, 2006

2. WCAP-16530-NP, Rev. 0, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," February 2006

3. LA-UR-05-6996, "Integrated Chemical Effects Test: Test #3 Data Report," October 2005

4. PA-SEE-0285, "Alternate Buffer for ECCS," February 2006

5. WCAP-16596-NP, Rev. 0, "Evaluation of Alternative Emergency Core Cooling System Buffering Agents," July 2006

6. FCS Updated Safety Analysis Report (USAR), Section 4.4.3

7. FCS Updated Safety Analysis Report (USAR), Section 14.15.6

8. Letter from Daniel S. Collins (US-NRC) to James A. Gresham (Westinghouse) Clarification of NRC Letter Dated August 1, 2005, Suspension of NRC Approval for Use of Westinghouse Topical Report CENPD-254-P, "Post-LOCA Long-Term

Cooling Model," Due to Discovery of Non-Conservative Modeling Assumptions During Calculations Audit (TAC No. MB1365), November 23, 2005

9. L-05-112, Letter from First Energy Nuclear Operating Company to USNRC, "Beaver Valley Power Station Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License NO. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, Responses to a Request for Additional Information in Support of License Amendment Request Nos. 302 and 173," July 8, 2005

10. W3F1-2005-0007, Letter from R. A. Dodds (Entergy) to US-NRC Document Control Desk, "Supplement to Amendment Request NPF-38-249, Extended Power Uprate, Waterford Steam Electric Station, Unit 3, Docket No. 50-382, License No. NPF-38", February 5, 2005

11. FCS Updated Safety Analysis Report (USAR), Section 14.15.8

12. NUREG-1431, Rev. 3, Volume 2, "Standard Technical Specifications, Westinghouse Plants

13. LTR-LIS-06-454, "Fort Calhoun Unit 1 TSP Replacement LAR Input for HLSO," August 1, 2006

14. LA-UR-05-9177, "Integrated Chemical Effects Test Project: Test #5 Data Report," January 2006

15. Oras, J., et al., "Chemical Effects/Head Loss Testing Quick Look Report, Tests ICET 3-4 to 11," January 20, 2006

16. PED-NEI-4, "Interface Requirements for Reload Analysis Process"

Requested Changes to Technical Specifications for FCS Facility Operating License No. DPR-40

TECHNICAL SPECIFICATIONS - FIGURES

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2.0 **LIMITING CONDITIONS FOR OPERATION**
2.3 Emergency Core Cooling System (Continued)

(3) Protection Against Low Temperature Overpressurization

The following limiting conditions shall be applied during scheduled heatups and cooldowns. Disabling of the HPSI pumps need not be required if the RCS is vented through at least a 0.94 square inch or larger vent.

Whenever the reactor coolant system cold leg temperature is below 350°F, at least one (1) HPSI pump shall be disabled.

Whenever the reactor coolant system cold leg temperature is below 320°F, at least two (2) HPSI pumps shall be disabled.

Whenever the reactor coolant system cold leg temperature is below 270°F, all three (3) HPSI pumps shall be disabled.

In the event that no charging pumps are operable when the reactor coolant system cold leg temperature is below 270°F, a single HPSI pump may be made operable and utilized for boric acid injection to the core, with flow rate restricted to no greater than 120 gpm.

(4) Containment Sump Buffering Agent Specification and Volume Requirement* ~~Trisodium Phosphate (TSP)~~

During operating Modes 1 and 2, the containment sump buffering agent~~TSP~~ baskets shall contain a volume of hydrated sodium tetraborate (NaTB)~~active TSP~~ that is within the area of acceptable operation shown in Figure 2-3.

a. With the above buffering agent~~TSP~~ requirements not within limits, the buffering agent~~TSP~~ shall be restored within 72 hours.

b. With Specification 2.3(4)a required action and completion time not met, the plant shall be in hot shutdown within the next 6 hours and cold shutdown within the following 36 hours.

Basis

The normal procedure for starting the reactor is to first heat the reactor coolant to near operating temperature by running the reactor coolant pumps. The reactor is then made critical. The energy stored in the reactor coolant during the approach to criticality is substantially equal to that during power operation and therefore all engineered safety features and auxiliary cooling systems are required to be fully operable.

*This Specification is applicable only for Fuel Cycle 24.

2.0 **LIMITING CONDITIONS FOR OPERATION**

2.3 Emergency Core Cooling System (Continued)

With respect to the core cooling function, there is functional redundancy over most of the range of break sizes.[(3)(4)]

The LOCA analysis confirms adequate core cooling for the break spectrum up to and including the 32 inch double-ended break assuming the safety injection capability which most adversely affects accident consequences and are defined as follows. The entire contents of all four safety injection tanks are assumed to be available for emergency core cooling, but the contents of one of the tanks is assumed to be lost through the reactor coolant system. In addition, of the three high-pressure safety injection pumps and the two low-pressure safety injection pumps, for both large break analysis and small break analysis it is assumed that one high pressure pump and one low pressure pump operate[(5)]; and also that 25% of their combined discharge rate is lost from the reactor coolant system out of the break. The transient hot spot fuel clad temperatures for the break sizes considered are shown in USAR Section 14.

The restriction on HPSI pump operability at low temperatures, in combination with the PORV setpoints ensure that the reactor vessel pressure-temperature limits would not be exceeded in the case of an inadvertent actuation of the operable HPSI and charging pumps.

Removal of the reactor vessel head, one pressurizer safety valve, or one PORV provides sufficient expansion volume to limit any of the design basis pressure transients. Thus, no additional relief capacity is required.

Technical Specification 2.2(1) specifies that, when fuel is in the reactor, at least one flow path shall be provided for boric acid injection to the core. Should boric acid injection become necessary, and no charging pumps are operable, operation of a single HPSI pump would provide the required flow path. The HPSI pump flow rate must be restricted to that of three charging pumps in order to minimize the consequences of a mass addition transient while at low temperatures.

Hydrated Sodium Tetraborate (NaTB)~~Trisodium Phosphate (TSP)~~ is required to adjust the pH of the recirculation water to ≥ 7.0 after a loss of coolant accident (LOCA). This pH value is necessary to prevent significant amounts of iodine, released from fuel failures and dissolved in the recirculation water, from converting to a volatile form and evolving into the containment atmosphere. Higher levels of airborne iodine in containment may increase the releases of radionuclides and the consequences of the accident. A pH of ≥ 7.0 is also necessary to prevent stress corrosion cracking (SCC) of austenitic stainless steel components in containment. SCC increases the probability of failure of components.

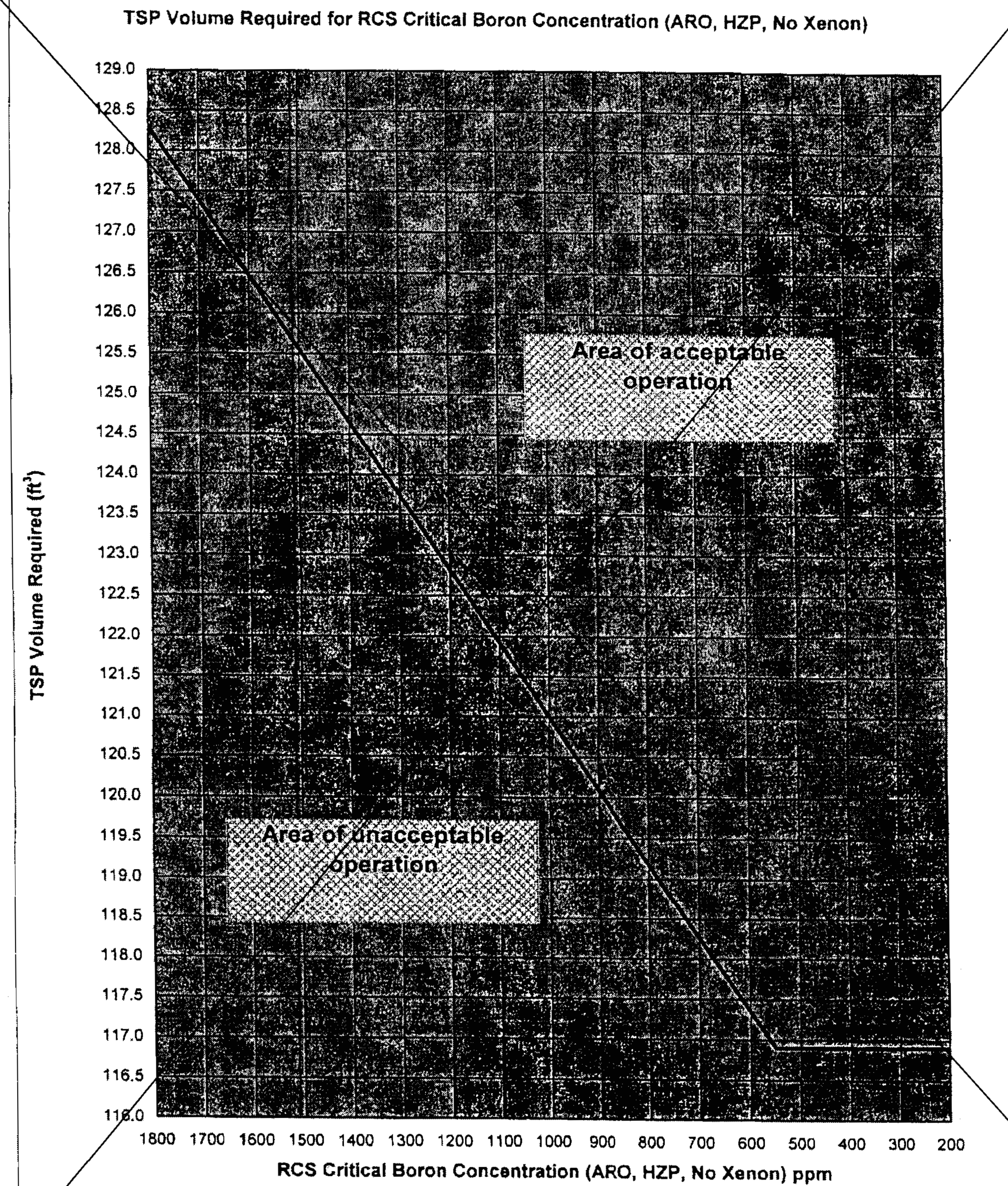
NaTB~~The hydrated form (45-57% moisture) of TSP~~ is used because of the high humidity in the containment building during normal operation. Since the NaTB~~TSP~~ is hydrated, it is less likely to absorb large amounts of water from the humid atmosphere and will undergo less physical and chemical change~~ than the anhydrous form of TSP~~.

Radiation levels in containment following a LOCA may cause the generation of hydrochloric and nitric acids from radiolysis of cable insulation and sump water. NaTB~~TSP~~ will neutralize these acids.

The required amount of NaTB~~TSP~~ is represented in a volume quantity converted from the Reference 7 mass quantity using the manufactured density. Verification of this amount during surveillance testing utilizes the measured volume.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.3 Emergency Core Cooling System (Continued)

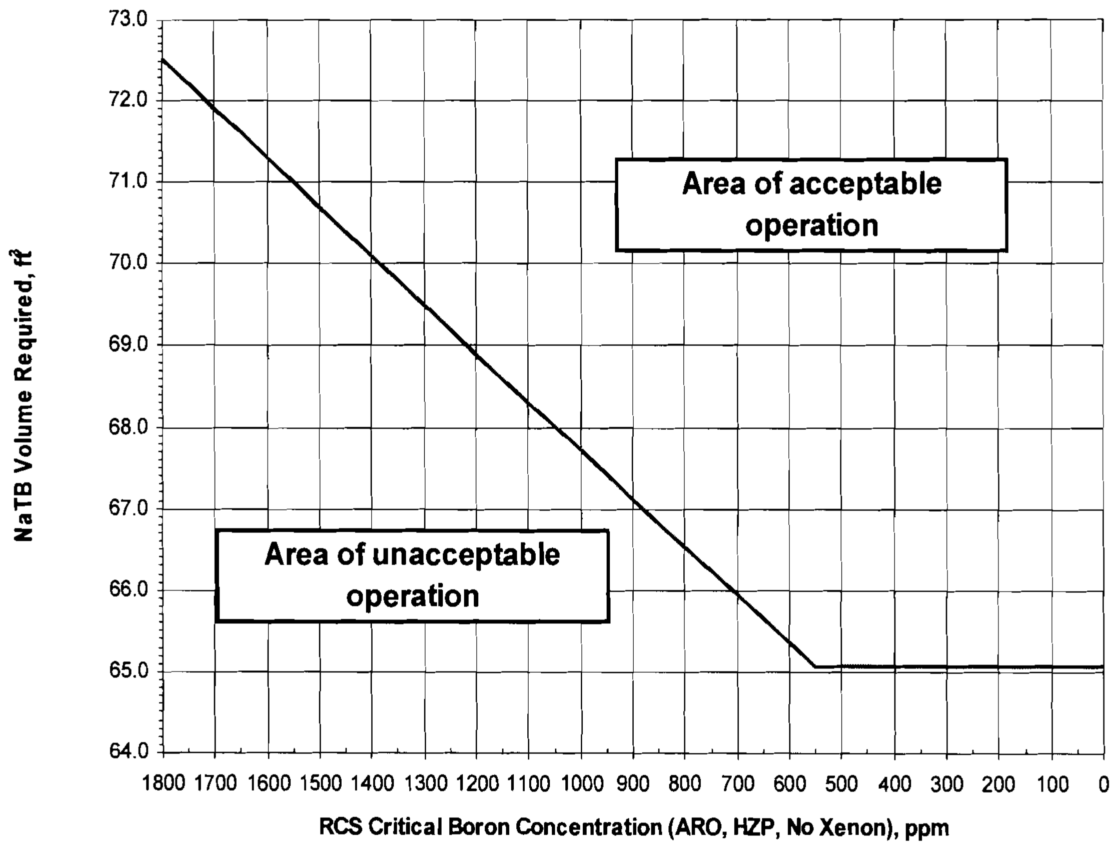
Figure 2-3



2.0 **LIMITING CONDITIONS FOR OPERATION**
2.3 Emergency Core Cooling System (Continued)

Figure 2-3

NaTB Volume Required for RCS Critical Boron Concentration (ARO, HZP, No Xenon)



3.0 **SURVEILLANCE REQUIREMENTS**
3.6 Safety Injection and Containment Cooling Systems Tests

Applicability

Applies to the safety injection system, the containment spray system, the containment cooling system and air filtration system inside the containment.

Objective

To verify that the subject systems will respond promptly and perform their intended functions, if required.

Specifications

(1) Safety Injection System

System tests shall be performed on a refueling frequency. A test safety feature actuation signal will be applied to initiate operation of the system. The safety injection and shutdown cooling system pump motors may be de-energized for this portion of the test.

A second overlapping test will be considered satisfactory if control board indication and visual observations indicate all components have received the safety feature actuation signal in the proper sequence and timing (i.e., the appropriate pump breakers shall have opened and closed, and all valves shall have completed their travel).

(2) Containment Spray System

a. System tests shall be performed on a refueling frequency. The test shall be performed with the isolation valves in the spray supply lines at the containment blocked closed. Operation of the system is initiated by tripping the normal actuation instrumentation.

b. At least every ten years the spray nozzles shall be verified to be open.

c. The test will be considered satisfactory if:

(i) Visual observations indicate that at least 264 nozzles per spray header have operated satisfactorily.

(ii) No more than one nozzle per spray header is missing.

d.* Representative samples of Hydrated Sodium Tetraborate (NaTB)~~Trisodium Phosphate Dodecahydrate (TSP)~~ that have been exposed to the same environmental conditions as that in the mesh baskets shall be tested on a refueling frequency by:

*This Specification is applicable only for Fuel Cycle 24.

3.0 SURVEILLANCE REQUIREMENTS

3.6 Safety Injection and Containment Cooling Systems Tests (continued)

(ii) Verifying that the containment sump buffering agent~~trisodium phosphate (TSP)~~ baskets contain a volume of granular NaTB~~TSP~~ that is within the area of acceptable operation of Figure 2-3.

(ii) Verifying that a sample from the buffering agent~~TSP~~ baskets provides adequate pH upward adjustment of the recirculation water.

3.0 SURVEILLANCE REQUIREMENTS

3.6 Safety injection and Containment Cooling Systems Tests (Continued)

Operation of the system for 10 hours every month will demonstrate operability of the filters and adsorbers system and remove excessive moisture build-up on the adsorbers.

Demonstration of the automatic initiation capability will assure system availability.

Determination of the volume of buffering agent in containment must be performed due to the possibility of leaking valves and components in the containment building that could cause dissolution of the buffering agent during normal operation.

A refueling frequency shall be utilized to visually determine that the volume of buffering agent contained in the buffering agent baskets is within the area of acceptable operation based on the buffering agent volume required by Figure 2-3. A measured value or the Technical Data Book (TDB) II, "Reactivity Curves" may be used to obtain a hot zero power (HZP) critical boron concentration (CBC). The "as found" volume of buffering agent must be within the area of acceptable operation of Figure 2-3 using this HZP CBC value. Prior to exiting the refueling outage, visual buffering agent volume determination is performed to ensure that the "as-left" volume of buffering agent contained in the baskets is ≥72.5 ft^3. This requirement ensures that there is an adequate quantity of buffering agent to adjust the pH of the post-LOCA sump solution to a value ≥ 7.0 for HZP CBC up to 1800 ppm.

Testing must be performed to ensure the solubility and buffering ability of the NaTB after exposure to the containment environment. A representative sample of 1.05 to 1.08 grams of NaTB from one of the baskets in containment is submerged in 0.99 – 1.01 liters of water at a boron concentration of 2436 – 2456 ppm (equivalent to a RCS boron concentration of 1800 ppm - Figure 2-3) using boric acid. At a standard temperature of 115 – 125°F, without agitation, the solution must be left to stand for 4 hours. The liquid is then decanted and mixed, the temperature is adjusted to 75 – 79°F and the pH measured. At this point, the pH must be ≥ 7.0. The representative sample weight is based on the minimum required NaTB weight of 4301 pounds, less the quantity required to account for acidic radiolysis products (758 pounds), and maximum possible post-LOCA sump volume of 398,445 gallons, normalized to a 1.0 liter sample. At a manufactured density of 59.3 lb_m/ft^3, 4301 pounds corresponds to the minimum volume of 72.5 ft^3.

For dissolution testing, the boron concentration of the test water is representative of the maximum possible boron concentration corresponding to the maximum possible post-LOCA sump volume. The post-LOCA sump volume originates from the Reactor Coolant System (RCS), the Safety Injection Refueling Water Tank (SIRWT), the Safety Injection Tanks (SITs) and the Boric Acid Storage Tanks (BASTs). The maximum post-LOCA sump boron concentration is based on a cumulative boron concentration in the RCS, SIRWT, SITs and BASTs of 2446 ppm. The cumulative boron concentration is based on a maximum RCS HZP CBC with no Xenon at Beginning of Cycle conditions, SIRWT and SIT boron concentrations at maximum allowed values of 2,350 ppm and maximum BAST concentration of 4.5 % wt. Agitation of the test solution is prohibited since an adequate standard for the agitation intensity cannot be specified. The test time of 4 hours is necessary to allow time for the dissolved NaTB to naturally diffuse through the sample solution. In the post-LOCA containment sump, rapid mixing would occur, significantly decreasing the

actual amount of time before the required pH is achieved. This would ensure achieving a pH ≥ 7.0 by the onset of recirculation after a LOCA.

~~Periodic determination of the volume of TSP in containment must be performed due to the possibility of leaking valves and components in the containment building that could cause dissolution of the TSP during normal operation.~~

~~A refueling frequency shall be utilized to visually determine that the volume of TSP contained in the TSP baskets is within the area of acceptable operation based on the TSP volume required by Figure 2-3. A measured value or the Technical Data Book (TDB) II, "Reactivity Curves" may be used to obtain a hot zero power (HZP) critical boron concentration (CBC). The "as found" volume of TSP must be within the area of acceptable operation of Figure 2-3 using this HZP CBC value. Prior to exiting the refueling outage, another visual TSP volume determination is performed to ensure that the "as-left" volume of TSP contained in the baskets is ≥128.3 ft^3. This requirement ensures that there is an adequate quantity of TSP to adjust the pH of the post-LOCA sump solution to a value ≥ 7.0 for HZP CBC up to 1800 ppm.~~

~~The periodic pH verification is also required on a refueling frequency. Operating experience has shown this surveillance frequency acceptable due to margin in the volume of TSP placed in the containment building.~~

~~An "as left" representative sample of 1.78 -1.81 grams of TSP from one of the baskets in containment is submerged in 0.99-1.01 liters of water at a boron concentration of 2439 - 2459 ppm (equivalent to a RCS boron concentration of 1800 ppm - Figure 2-3). At a standard temperature of 115-125°F, without agitation, the solution should be left to stand for 4 hours. The liquid is then decanted and mixed, the temperature adjusted to 75 - 79°F and the pH measured. At this point the pH must be ≥ 7.0. The representative sample weight is based on the minimum required TSP weight at the beginning of cycle of 6,800 lbs$_m$, which, at a manufactured density of at least 53.0 lb$_m$/ft^3 corresponds to the minimum volume of 128.3 ft^3, and maximum possible post-LOCA sump volume of 397,183 gallons, normalized to buffer a 1.0 liter sample.~~

3.0 **SURVEILLANCE REQUIREMENTS**
3.6 Safety injection and Containment Cooling Systems Tests (Continued)

~~Testing of the "as found" condition must be performed to ensure the solubility and buffering ability of the TSP after exposure to the containment environment. The "as found" test is performed in the same manner as the "as left" test. However, a different sample size and boron concentration is used based on the end of cycle HZP CBC. The representative sample size, boron concentration of sample water, minimum required TSP weight, and minimum volume of TSP are all a function of the end of cycle HZP CBC as specified in EA-FC-03-041. The "as found" volume of TSP corresponds to the maximum possible boron concentration corresponding to the maximum possible post-LOCA sump volume of 397,183 gallons, normalized to a buffer a 1.0 liter sample.~~

~~The boron concentration of the test water is representative of the maximum possible boron concentration corresponding to the maximum possible post-LOCA sump volume. The post-LOCA sump volume originates from the Reactor Coolant System (RCS), the Safety injection Refueling Water Tank (SIRWT), the Safety injection Tanks (SITs) and the Boric Acid Storage Tanks (BASTs). The maximum post-LOCA sump boron concentration is based on a cumulative boron concentration in the RCS, SIRWT, SITs and BASTs of 2449 ppm at beginning of cycle (HZP CBC = 1800 ppm) and 2333 ppm at end of cycle (HZP CBC ≤ 550 ppm). These values are based on the SIRWT and SITs at 2350 ppm and the BASTS at 4.5 wt. % boron. Agitation of the test solution is prohibited, since an adequate standard for the agitation intensity cannot be specified. The test time of 4 hours is necessary to allow time for the dissolved TSP to naturally diffuse through the sample solution. In the post-LOCA containment sump, rapid mixing would occur, significantly decreasing the actual amount of time before the required pH is achieved. This would ensure achieving a pH ≥ 7.0 by the onset of recirculation after a LOCA.~~

References

(1) USAR, Section 6.2
(2) USAR, Section 6.3
(3) USAR, Section 14.16
(4) USAR, Section 6.4
~~(5) EA-FC-03-041, 10114103, "Minimum Trisodium Phosphate (TSP) Volume Required in Containment Sump as a Function of RCS Critical Boron Concentration (ARO, HZP, No Xenon)"~~

Proposed Technical Specifications for FCS Facility Operating License No. DPR-40

TECHNICAL SPECIFICATIONS - FIGURES

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2.0 **LIMITING CONDITIONS FOR OPERATION**

2.3 Emergency Core Cooling System (Continued)

(3) Protection Against Low Temperature Overpressurization

The following limiting conditions shall be applied during scheduled heatups and cooldowns. Disabling of the HPSI pumps need not be required if the RCS is vented through at least a 0.94 square inch or larger vent.

Whenever the reactor coolant system cold leg temperature is below 350°F, at least one (1) HPSI pump shall be disabled.

Whenever the reactor coolant system cold leg temperature is below 320°F, at least two (2) HPSI pumps shall be disabled.

Whenever the reactor coolant system cold leg temperature is below 270°F, all three (3) HPSI pumps shall be disabled.

In the event that no charging pumps are operable when the reactor coolant system cold leg temperature is below 270°F, a single HPSI pump may be made operable and utilized for boric acid injection to the core, with flow rate restricted to no greater than 120 gpm.

(4) Containment Sump Buffering Agent Specification and Volume Requirement*

During operating Modes 1 and 2, the containment sump buffering agent baskets shall contain a volume of active hydrated sodium tetraborate (NaTB) that is within the area of acceptable operation shown in Figure 2-3.

a. With the above buffering agent requirements not within limits, the buffering agent shall be restored within 72 hours.

b. With Specification 2.3(4)a required action and completion time not met, the plant shall be in hot shutdown within the next 6 hours and cold shutdown within the following 36 hours.

Basis

The normal procedure for starting the reactor is to first heat the reactor coolant to near operating temperature by running the reactor coolant pumps. The reactor is then made critical. The energy stored in the reactor coolant during the approach to criticality is substantially equal to that during power operation and therefore all engineered safety features and auxiliary cooling systems are required to be fully operable.

* This Specification is applicable only for Fuel Cycle 24.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.3 Emergency Core Cooling System (Continued)

With respect to the core cooling function, there is functional redundancy over most of the range of break sizes.(3)(4)

The LOCA analysis confirms adequate core cooling for the break spectrum up to and including the 32 inch double-ended break assuming the safety injection capability which most adversely affects accident consequences and are defined as follows. The entire contents of all four safety injection tanks are assumed to be available for emergency core cooling, but the contents of one of the tanks is assumed to be lost through the reactor coolant system. In addition, of the three high-pressure safety injection pumps and the two low-pressure safety injection pumps, for both large break analysis and small break analysis it is assumed that one high pressure pump and one low pressure pump operate(5); and also that 25% of their combined discharge rate is lost from the reactor coolant system out of the break. The transient hot spot fuel clad temperatures for the break sizes considered are shown in USAR Section 14.

The restriction on HPSI pump operability at low temperatures, in combination with the PORV setpoints ensure that the reactor vessel pressure-temperature limits would not be exceeded in the case of an inadvertent actuation of the operable HPSI and charging pumps.

Removal of the reactor vessel head, one pressurizer safety valve, or one PORV provides sufficient expansion volume to limit any of the design basis pressure transients. Thus, no additional relief capacity is required.

Technical Specification 2.2(1) specifies that, when fuel is in the reactor, at least one flow path shall be provided for boric acid injection to the core. Should boric acid injection become necessary, and no charging pumps are operable, operation of a single HPSI pump would provide the required flow path. The HPSI pump flow rate must be restricted to that of three charging pumps in order to minimize the consequences of a mass addition transient while at low temperatures.

Hydrated Sodium Tetraborate (NaTB) is required to adjust the pH of the recirculation water to ≥ 7.0 after a loss of coolant accident (LOCA). This pH value is necessary to prevent significant amounts of iodine, released from fuel failures and dissolved in the recirculation water, from converting to a volatile form and evolving into the containment atmosphere. Higher levels of airborne iodine in containment may increase the releases of radionuclides and the consequences of the accident. A pH of ≥ 7.0 is also necessary to prevent stress corrosion cracking (SCC) of austenitic stainless steel components in containment. SCC increases the probability of failure of components.

NaTB is used because of the high humidity in the containment building during normal operation. Since the NaTB is hydrated, it is less likely to absorb large amounts of water from the humid atmosphere and will undergo less physical and chemical change.

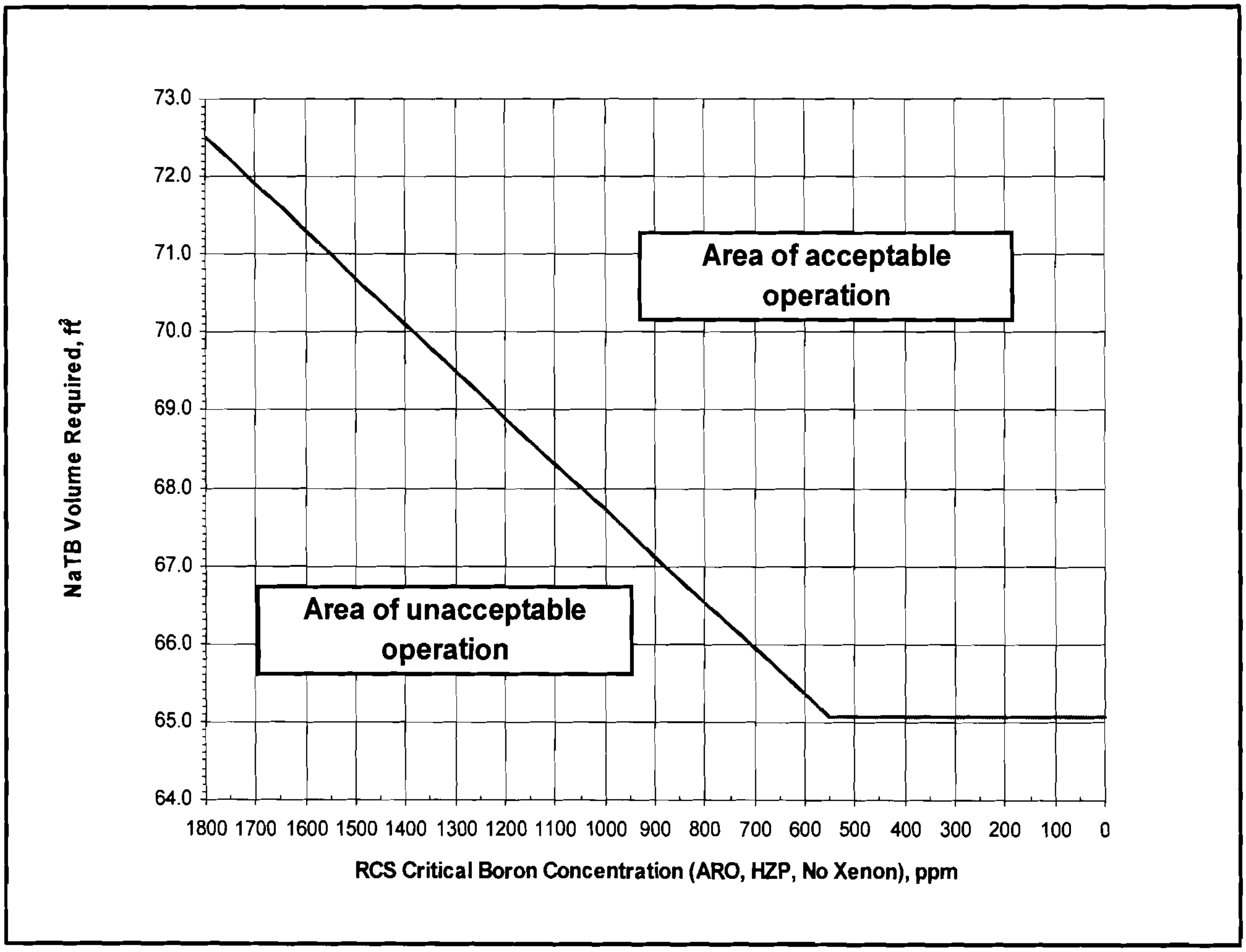
Radiation levels in containment following a LOCA may cause the generation of hydrochloric and nitric acids from radiolysis of cable insulation and sump water. NaTB will neutralize these acids.

The required amount of NaTB is represented in a volume quantity converted from the Reference 7 mass quantity using the manufactured density. Verification of this amount during surveillance testing utilizes the measured volume.

2.0 **LIMITING CONDITIONS FOR OPERATION**
2.3 Emergency Core Cooling System (Continued)

Figure 2-3

NaTB Volume Required for RCS Critical Boron Concentration (ARO, HZP, No Xenon)



3.0 **SURVEILLANCE REQUIREMENTS**

3.6 Safety Injection and Containment Cooling Systems Tests

Applicability

Applies to the safety injection system, the containment spray system, the containment cooling system and air filtration system inside the containment.

Objective

To verify that the subject systems will respond promptly and perform their intended functions, if required.

Specifications

(1) Safety Injection System

System tests shall be performed on a refueling frequency. A test safety feature actuation signal will be applied to initiate operation of the system. The safety injection and shutdown cooling system pump motors may be de-energized for this portion of the test.

A second overlapping test will be considered satisfactory if control board indication and visual observations indicate all components have received the safety feature actuation signal in the proper sequence and timing (i.e., the appropriate pump breakers shall have opened and closed, and all valves shall have completed their travel).

(2) Containment Spray System

a. System tests shall be performed on a refueling frequency. The test shall be performed with the isolation valves in the spray supply lines at the containment blocked closed. Operation of the system is initiated by tripping the normal actuation instrumentation.

b. At least every ten years the spray nozzles shall be verified to be open.

c. The test will be considered satisfactory if:

(i) Visual observations indicate that at least 264 nozzles per spray header have operated satisfactorily.

(ii) No more than one nozzle per spray header is missing.

d.* Representative samples of Hydrated Sodium Tetraborate (NaTB) that have been exposed to the same environmental conditions as that in the mesh baskets shall be tested on a refueling frequency by:

* This Specification is applicable only for Fuel Cycle 24.

3.0 SURVEILLANCE REQUIREMENTS

3.6 Safety Injection and Containment Cooling Systems Tests (continued)

(i) Verifying that the containment sump buffering agent baskets contain a volume of granular NaTB that is within the area of acceptable operation of Figure 2-3.

(ii) Verifying that a sample from the buffering agent baskets provides adequate pH upward adjustment of the recirculation water.

3.0 **SURVEILLANCE REQUIREMENTS**

3.6 Safety injection and Containment Cooling Systems Tests (Continued)

Operation of the system for 10 hours every month will demonstrate operability of the filters and adsorbers system and remove excessive moisture build-up on the adsorbers.

Demonstration of the automatic initiation capability will assure system availability.

Determination of the volume of buffering agent in containment must be performed due to the possibility of leaking valves and components in the containment building that could cause dissolution of the buffering agent during normal operation.

A refueling frequency shall be utilized to visually determine that the volume of buffering agent contained in the buffering agent baskets is within the area of acceptable operation based on the buffering agent volume required by Figure 2-3. A measured value or the Technical Data Book (TDB) II, "Reactivity Curves" may be used to obtain a hot zero power (HZP) critical boron concentration (CBC). The "as found" volume of buffering agent must be within the area of acceptable operation of Figure 2-3 using this HZP CBC value. Prior to exiting the refueling outage, visual buffering agent volume determination is performed to ensure that the "as-left" volume of buffering agent contained in the baskets is ≥72.5 ft^3. This requirement ensures that there is an adequate quantity of buffering agent to adjust the pH of the post-LOCA sump solution to a value ≥ 7.0 for HZP CBC up to 1800 ppm.

Testing must be performed to ensure the solubility and buffering ability of the NaTB after exposure to the containment environment. A representative sample of 1.05 to 1.08 grams of NaTB from one of the baskets in containment is submerged in 0.99 – 1.01 liters of water at a boron concentration of 2436 – 2456 ppm (equivalent to a RCS boron concentration of 1800 ppm - Figure 2-3) using boric acid. At a standard temperature of 115 – 125°F, without agitation, the solution must be left to stand for 4 hours. The liquid is then decanted and mixed, the temperature is adjusted to 75 – 79°F and the pH measured. At this point, the pH must be ≥ 7.0. The representative sample weight is based on the minimum required NaTB weight of 4301 pounds, less the quantity required to account for acidic radiolysis products (758 pounds), and maximum possible post-LOCA sump volume of 398,445 gallons, normalized to a 1.0 liter sample. At a manufactured density of 59.3 lb_m/ft^3, 4301 pounds corresponds to the minimum volume of 72.5 ft^3.

For dissolution testing, the boron concentration of the test water is representative of the maximum possible boron concentration corresponding to the maximum possible post-LOCA sump volume. The post-LOCA sump volume originates from the Reactor Coolant System (RCS), the Safety Injection Refueling Water Tank (SIRWT), the Safety Injection Tanks (SITs) and the Boric Acid Storage Tanks (BASTs). The maximum post-LOCA sump boron concentration is based on a cumulative boron concentration in the RCS, SIRWT, SITs and BASTs of 2446 ppm. The cumulative boron concentration is based on a maximum RCS HZP CBC with no Xenon at Beginning of Cycle conditions, SIRWT and SIT boron concentrations at maximum allowed values of 2,350 ppm and maximum BAST concentration of 4.5 % wt. Agitation of the test solution is prohibited since an adequate standard for the agitation intensity cannot be specified. The test time of 4 hours is necessary to allow time for the dissolved NaTB to naturally diffuse through the sample solution. In the post-LOCA containment sump, rapid mixing would occur, significantly decreasing the actual amount of time before the required pH is achieved. This would ensure achieving a pH ≥ 7.0 by the onset of recirculation after a LOCA.

3.0 **SURVEILLANCE REQUIREMENTS**
3.6 Safety injection and Containment Cooling Systems Tests (Continued)

References

(1) USAR, Section 6.2
(2) USAR, Section 6.3
(3) USAR, Section 14.16
(4) USAR, Section 6.4

LTR-CDME-06-115, Rev. 0, "Summary Report for Testing of Alternative Emergency Core Coolant System Buffering Agents for Fort Calhoun Station"

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Summary Report for Testing of Alternative Emergency Core Coolant System Buffering Agents for Fort Calhoun Station

Introduction

In the event of a loss of coolant accident (LOCA) at the Omaha Public Power District's (OPPD) Fort Calhoun Station (FCS), core cooling would be provided by the Emergency Core Cooling System (ECCS). In operation, ECCS coolant circulation flow is partially provided by the High Pressure Safety Injection (HPSI) pumps, which take suction from the containment sump through a set of sump strainers (Reference 1). The potential for sump strainer blockage due to debris either generated during the LOCA has been identified as a generic safety concern (Reference 2).

Currently, the ECCS coolant at FCS contains boric acid for reactivity control, and following RAS trisodium phosphate (TSP) is dissolved in the post-LOCA containment sump fluid mixture to adjust the pH to greater than 7.0. The adjustment of pH is performed primarily to maintain fission product iodine in solution. Below pH 6.5, iodine may come out of solution as iodine gas, and eventually be released to the environment, resulting in increased off site radiation exposure (Reference 3). As a side benefit, maintaining pH above 7.0 reduces general corrosion of structural materials in containment, particularly aluminum and carbon/low alloy steels. It also reduces the potential for localized attack of austenitic stainless steel system components by aggressive species such as chloride (e.g., chloride induced stress corrosion cracking).

In the event of a LOCA, containment materials that are not normally wetted may either be contacted by containment spray or become fully submerged in the containment sump pool. Testing and industry data (Reference 16) has demonstrated that these materials will release a variety of chemical species due to dissolution or corrosion (References 4 and 5) or destruction from the pipe break. The predominant dissolved species are calcium, aluminum and silicate. These species may combine with each other to produce precipitates (e.g., sodium aluminum silicate) or combine with TSP to produce calcium phosphate. Any such precipitates generated may potentially combine with other types of debris in the system which would increase the severity of sump strainer blockage.

Due to the large quantity of calcium silicate insulation debris that may be generated during a LOCA at FCS, a correspondingly large quantity of calcium phosphate precipitate could be generated. Therefore, OPPD has undertaken a program to evaluate switching from TSP to an alternative buffering agent.

In addition to minimizing precipitate generation, the following properties must be comparable to those of TSP:

1. Quantity required to adjust pH to >7.0, particularly, the required volume should fit in existing baskets
2. Complete dissolution in hot (150°F) water in less than four hours
3. Affordability and ready availability
4. No demonstrated deleterious effects, e.g., corrosion to key containment structural materials
5. Does not adversely affect the solubility of boric acid, or lead to an increase in boric acid precipitation on structures
6. Resistant to degradation from radiation, elevated temperatures and humidity (storage life)
7. Material does not create habitability concerns during storage or handling

Issues associated with the ECCS buffering agents currently used in Pressurized Water Reactors (PWR) are a generic industry concern. Therefore, the PWR Owners Group sponsored a program to evaluate alternative buffering agents for ECCS applications in all PWRs (Reference 6). The results of this evaluation were reported in Reference 7. The study concluded that sodium tetraborate decahydrate (NaTB or Borax) was a suitable replacement for plants currently using TSP. A discussion of the properties of NaTB relative to TSP is provided in the succeeding sections of this report.

Comparison of NaTB to TSP

Quantity Required to Adjust pH above 7.0

The quantity of buffering agent required to adjust pH to greater than 7.0 is determined at the maximum reactor coolant system boron concentration at the beginning of the operating cycle and at the maximum sump volume. Additional buffering agent must also be included to neutralize acids that may be generated from radiolysis of water and air (nitric acid, HNO_3) and radiolysis of electric cable jacket material (hydrochloric acid, HCl). On a mass basis, the quantity of NaTB required to neutralize radiolytically generated acids is comparable to the quantity of TSP required since the molecular weights are nearly identical (380 grams per mole for TSP and 381 grams per mole for NaTB). For pH values less than 7.8, the quantity of NaTB required to adjust the pH of a boric acid solution is less than the quantity of TSP required. Above this value, relatively more NaTB is required to achieve an equivalent pH.

From Reference 8, the maximum RCS boron concentration is 1800 ppm. The maximum quantity of fluid in the sump pool is 398,445 gallons. (Reference 9) This includes the inventory of the Reactor Coolant System (RCS) , Safety Injection Refueling Water Tank (SIRWT), the Safety Injection Tanks (SITs) and the Boric Acid Storage Tanks (BASTs). The maximum post-LOCA sump boron concentration is based on a cumulative boron concentration in the RCS, SIRWT, SITs and BASTs of 2446 ppm. Under these conditions, a total of 3543 pounds (1611 kg) of NaTB is required to adjust the pH of the water in the sump pool to 7.0 or greater. An additional 758 pounds (344.3 kg) is required to neutralize radiolytically produced acids. Thus, a total of 4301 pounds (1955 kg) of NaTB should be loaded in the buffering agent baskets (Reference 9). At a bulk (manufactured) minimum density of 59.3 pounds/ft^3 (Reference 10),

4301 pounds of NaTB corresponds to 72.5 ft^3. Currently, 128.3 ft^3 of TSP is stored in the FCS buffering agent baskets. At a bulk density of 53 pounds/ft^3, this equates to 6800 pounds. Thus, the required quantity of NaTB will easily fit in the buffering agent baskets currently installed in the FCS containment.

In the current hydrogen generation evaluation at FCS, the maximum evaluated ECCS pH is 7.5 (Reference 8). At the minimum possible sump boron concentration of 1681 ppm and minimum sump volume of 328,612 gallons, addition of 4755pounds of NaTB will result in a pH of 7.5 (Reference 9). This corresponds to a volume of 80.3 ft^3 at a bulk minimum density of 59.3 pounds/ft^3.

Dissolution Rate

As reported in Reference 7, the dissolution rates for NaTB and TSP were determined at a concentration of 10 grams per liter at 150°F. Testing was performed with both fresh product and product stored under simulated containment conditions for 30 days. For the fresh products, the dissolution rates were essentially the same for NaTB (2 minutes, 20 seconds) and TSP (2 minutes, 21 seconds). For the aged product, TSP dissolved somewhat faster than NaTB (2 minutes, 37 seconds versus 3 minutes, 29 seconds), but both readily dissolved.

Corrosion Inhibition

Both TSP and NaTB are used as corrosion inhibitors for carbon/low alloy steels (Reference 11). Thus, the steady state corrosion rates for these materials would be expected to be low for either buffer. As reported in Reference 7, corrosion of A508 Class 2 carbon steel was determined after exposure to buffered solutions at 150°F for 14 days. The measured corrosion in NaTB and TSP were essentially identical (1.03 g/m^2 for NaTB and 1.00 g/m^2 for TSP). Based on its higher corrosion resistance, corrosion to stainless steel would be one or more orders of magnitude lower, and neither NaTB nor other borates have been shown to cause localized corrosion attack in high chromium alloys such as stainless steel.

Corrosion of submerged aluminum is exceptionally low in TSP due to formation of an aluminum phosphate conversion coating. Corrosion of submerged aluminum in NaTB is higher since a comparable aluminum borate coating does not readily form. As reported in Reference 7, the measured values after 14 days exposure were 17.8 g/m^2 for NaTB and 0.55 g/m^2 for TSP. The overall effect of increased corrosion of submerged aluminum in the presence of NaTB relative to TSP is not significant since dissolved silicate will also inhibit corrosion of submerged aluminum. It should be noted that the inhibitory effects of phosphate and silicate are not included in the PWROG chemical model (Reference 12) since these effects have not been quantified for all chemistry conditions.

Boric Acid Solubility

As reported in Reference 7, both NaTB and TSP increase the solubility of boric acid. At an equivalent pH (7.0) and boron concentration (2500 ppm), the degree of increase in the presence of TSP is higher than in the presence of NaTB (16.4 percent for TSP versus 7.7 percent for NaTB). Thus, while NaTB does provide some additional margin against boric acid precipitation, the margin is lower than with TSP. Consequently, because NaTB is less effective than TSP at increasing the boric acid solubility limit, the hot leg switchover (HLSO) time must be recalculated for Fort Calhoun.

Environmental Stability

As reported in Reference 7, in the initial test of environmental stability, buffer samples were exposed to a simulated containment environment of 100 percent humidity at 150°F. However, after 14 days under

these conditions TSP liquefied completely, and thus the conditions were considered to be too severe. In the initial exposure, NaTB remained solid but did clump. The test was repeated at 30 percent humidity and 150°F. After 30 days under these conditions, clumping was observed in both TSP and NaTB, but both buffers readily dissolved in hot (150°F) water. The volume change due to settling/densification after exposure to these conditions was not quantified, but visually appeared to be similar for NaTB and TSP. On the basis of these results, the stability of NaTB in containment environment should be considered comparable to slightly better than TSP. NaTB has been used for many years in Ice Condenser plants and its stability to exposure to gamma radiation has been demonstrated to be good. In these plants, the NaTB is dissolved in ice that is stored in baskets in containment. Thus, the radiation fields to which the NaTB is subject in Ice Condenser plants is comparable to the fields to which the NaTB would be exposed at FCS. Additionally, a similar chemical (sodium pentaborate) is routinely stored in containments for emergency use in Boiling Water Reactor plants (Reference 13) and also shows no degradation due to radiation exposure over time.

Precipitate Formation

As reported in Reference 7, testing was performed to determine whether the buffering agents would react with aluminum or calcium to form precipitates. The testing was performed with both NaTB and TSP. The testing also investigated the condition under which precipitates would form, and the relative quantities. The test results showed that no precipitates formed in NaTB with addition of either metal at pH values of 8.0 or less. Precipitates formed in TSP with both metals irrespective of pH (only pH values greater than 7.0 were evaluated). At 150°F and pH 8.5, an aluminum borate precipitate formed with NaTB at aluminum concentrations in excess of 177 ppm, and a calcium borate precipitate formed at calcium concentration in excess of 254 ppm. The borate precipitates dissolved when pH was reduced to less than 8.0. Note that the borate precipitates did not form at ambient temperature at these aluminum or calcium concentrations. Since the nominal sump pH at FCS will be less than 8.0, there is no concern with borate precipitation. Additionally, the maximum predicted dissolved aluminum concentration at FCS is 22 ppm, and the maximum calcium concentration is 126 ppm. Both values are less than the applicable threshold values for precipitate formation at elevated pH. Finally, any precipitates formed under transient high pH/high local metal concentration conditions will re-dissolve in the presence of lower steady state pH conditions and thus would not contribute to sump screen blockage.

Under nominal conditions at FCS (pH 7.5, minimum sump volume), the PWROG model predicts formation of 227 kg of sodium aluminum silicate $NaAlSi_3O_8$ if either NaTB or TSP is used for buffering. With TSP, an additional 513 kg of calcium phosphate precipitate is generated. Thus, use of NaTB rather than TSP results in a net decrease of 69 percent in the quantity of precipitate generated (227 kg with NaTB versus 740 kg with TSP). Table 1 provides a summary of the predicted precipitate generation.

	NaTB pH 7.5		TSP pH 7.5	
	Max recirculation volume		Max recirculation volume	
	(kg)	(ppm)	(kg)	(ppm)
$NaAlSi_3O_8$	227.0	152.2	227.0	152.2
AlOOH	0.00	0.00	0.00	0.00
$Ca_3(PO_4)_2$	0.00	0.00	513.10	344.0

Table 1: Predicted Quantities of Precipitates in a Post-LOCA Environment for FCS (Reference 14)

Increased Boron for Reactivity Control

A serendipitous benefit to use of NaTB as an ECCS buffering agent is an increase in net boron for reactivity control. For a maximum sump volume of 398,445 gallons, addition of 1955 kilograms of NaTB will provide an additional 150 ppm boron for reactivity control. This represents an increase of about 8.95 percent for the minimum boron condition (1681 ppm boron). As noted above, the presence of additional boron as sodium tetraborate increases the solubility of boric acid.

Buffering Capacity

To determine the relative buffering capacity of NaTB and TSP, stock solutions of 1500 ppm boric acid were prepared and the pH was adjusted to 7.5 with either NaTB or TSP. In one test, solid boric acid (a weak acid) was added in 300 ppm increments and the resulting pH was measured. In a second test, a 1 molar (1M) hydrochloric acid solution (a strong acid) was added in 73 ppm increments. The results of this testing showed that NaTB and TSP have comparable buffering capacity (see Figures 1 and 2).

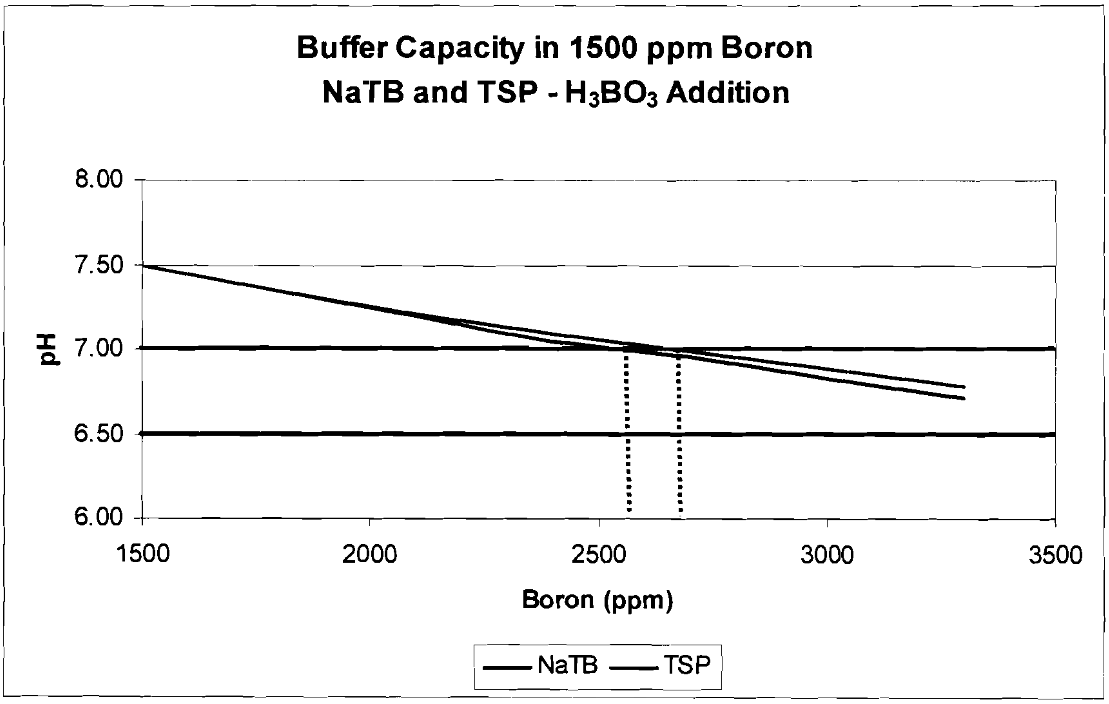

Figure 1: Buffering Capacity of NaTB and TSP for Boric Acid Addition

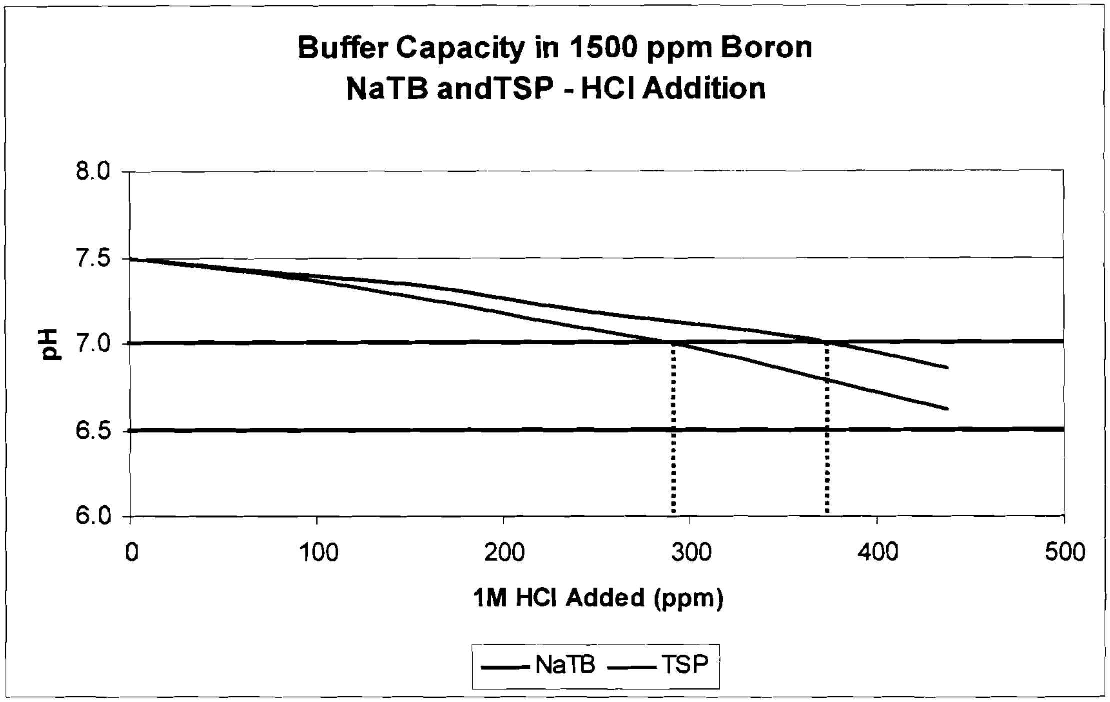

Figure 2: Buffering Capacity of NaTB and TSP for Hydrochloric Acid Addition

Summary

In summary, sodium tetraborate decahydrate (NaTB) is an acceptable alternative to trisodium phosphate dodecahydrate (TSP) for use as the ECCS buffering agent at FCS. Use of NaTB will result in a net reduction in precipitate formation of 69 percent, with no adverse side effects. Additionally, use of NaTB will provide additional dissolved boron for reactivity control.

- NaTB provides a comparable buffering capacity to TSP with a comparable quantity of buffering agent, so that no modification to the existing buffer delivery scheme would be required;
- no new types of precipitates are formed in the target pH of 7.0 to 8.0, irrespective of the calcium loading;
- corrosion of structural materials is comparable to that expected with TSP;
- as with TSP, NaTB addition increases the solubility of boric acid, and thereby provides contingency against boric acid precipitation under post-accident conditions;
- NaTB has been evaluated for other potential chemical effects as part of the PWROG Program (Reference 12) and the ICET program (References 4 and 5); and
- NaTB is already in use at ice condenser plants and has a long and acceptable track record.

Application Considerations

Buffer Surveillance

In accordance with Technical Specification 3.6.d, the buffering capability of the TSP stored in the containment buffering agent baskets must be periodically confirmed by performing bench scale testing of samples taken from the baskets. The revised text for performance of this testing for NaTB, the pH must be ≥ 7.0. The representative sample weight is based on the minimum required NaTB weight of 4301 pounds, less the quantity required to account for acidic radiolysis products (758 pounds), and maximum possible post-LOCA sump volume of 398,445 gallons, normalized to a 1.0 liter sample. At a manufactured minimum density of 59.3 lb_m/ft^3, 4301 pounds corresponds to the minimum volume of 72.5 ft^3. The boron concentration of the test water is representative of the maximum possible boron concentration corresponding to the maximum possible post-LOCA sump volume. The post-LOCA sump volume originates from the Reactor Coolant System (RCS), the Safety Injection Refueling Water Tank (SIRWT), the Safety Injection Tanks (SITs) and the Boric Acid Storage Tanks (BASTs). The maximum post-LOCA sump boron concentration is based on a cumulative boron concentration in the RCS, SIRWT, SITs and BASTs of 2446 ppm. Agitation of the test solution is prohibited since an adequate standard for the agitation intensity cannot be specified. The test time of 4 hours is necessary to allow time for the dissolved NaTB to naturally diffuse through the sample solution. In the post-LOCA containment sump, rapid mixing would occur, significantly decreasing the actual amount of time before the required pH is achieved. This would ensure achieving a pH ≥ 7.0 by the onset of recirculation after a LOCA."

Buffer Specifications

The preferred physical form for NaTB for ECCS application is granular crystals with a minimum sodium tetraborate decahydrate concentration of 98 percent. This product has a nominal bulk density of 62 pounds/ft^3, and is available from a variety of vendors (e.g., US Borax). Technical grade product will typically meet required specifications. For consistency with normal operating chemistry limits on impurities (Reference 15), chloride, fluoride and sulfate should be less than 100 ppm, and heavy metals (as lead) should be less than 5 ppm.

The decahydrate is the highest hydrated form of sodium tetraborate salt. Therefore, NaTB will not pick up additional waters of hydration during storage in areas with elevated humidity. In fact, if exposed to dry, warm air for extended periods NaTB may lose minor amounts of its waters of hydration. This behavior is termed efflorescence, and is typically noted on material safety data sheets/product data sheets for NaTB. However, in the conditions present in the FCS containment, NaTB, effloresce is not expected. Sodium tetraborate is also available in anhydrous form and as a pentahydrate. Although use of sodium tetraborate in these forms would likely be acceptable, testing would be required to determine the quantity required to adjust pH and environmental stability and addition of waters of hydration would need to be considered.

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