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October 3, 2006

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
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Serial No. 06-849
NL&OS/ETS R0
Docket Nos. 50-338/339
License Nos. NPF-4/7

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNITS 1 AND 2
PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

Pursuant to 10 CFR 50.90, Dominion hereby requests an amendment to Operating License Numbers NPF-4 and NPF-7 in the form of changes to the Technical Specifications (TS) for North Anna Power Station Units 1 and 2, respectively. The proposed change is being submitted as part of Dominion's resolution to NRC Generic Safety Issue 191 (GSI-191). In a letter dated September 1, 2005 (Serial No. 05-212), Dominion identified actions required to resolve GSI-191 and NRC Generic Letter (GL) 2004-02 for North Anna. In that letter, Dominion committed to provide this submittal in February 2006. In a subsequent phone conversation on December 14, 2005, Dominion advised the NRC that additional time was needed to complete the North Anna specific analysis and that the associated Technical Specification change and containment analysis for North Anna would be submitted by fall of 2006.

The actions required to resolve GSI-191 and GL 2004-02 are addressed by the proposed TS change and supporting safety analysis discussed in Attachment 1 and summarized in the following paragraphs. Attachment 1 of this letter provides the North Anna plant-specific applications of the DOM-NAF-3 methodology for changes to the recirculation spray (RS) pump start method and the containment air partial pressure operating limits in TS Figure 3.6.4-1. The marked up and proposed TS pages are provided in Attachments 2 and 3, respectively. The associated marked up and typed Bases changes are provided for information only in Attachments 4 and 5, respectively.

The proposed TS change revises the method for starting the inside and outside RS pumps in response to a design basis accident. Currently the North Anna RS pumps start using delay timers that are initiated when the containment pressure reaches the Containment Depressurization Actuation (CDA) High High set point. The change will start the RS pumps with a coincident CDA High High pressure and refueling water storage tank (RWST) Level Low. Other changes required to support the containment

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reanalysis and ensure net positive suction head include: lowering the containment operating temperature limit, modifying the containment partial air pressure operating limit, and lowering the plant setpoint and TS allowable values for the RWST Level Low Low function that initiates safety injection recirculation mode transfer. In addition, the TS change modifies the sump inspection requirements to reflect the new strainer configuration.

The proposed safety analysis change revises the North Anna containment analyses by converting from the present Stone and Webster LOCTIC computer code to the GOTHIC code (Topical Report DOM-NAF-3). On August 30, 2006, the NRC staff approved DOM-NAF-3, which documents the Dominion methodology for analyzing the containment response to postulated pipe ruptures. Attachment 1 of this letter provides the North Anna plant-specific applications of the DOM-NAF-3 methodology for changes to the RS pump start method and the containment air partial pressure and temperature operating limits in TS Figure 3.6.4-1.

An additional safety analysis change includes revisions to the LOCA Alternate Source Term (AST) dose consequences analysis that accommodate the changes to the RS pump start methodology. The changes to the RS pump start methodology result in a short-term increase in air leakage from the containment and a short-term reduction in spray removal of radioactive isotopes from the containment atmosphere. Attachment 1 of this letter also documents revisions to the LOCA dose consequences analysis.

Dominion requests NRC staff approval of the proposed TS change and supporting safety analyses revisions by February 15, 2007 in order to implement the proposed changes during the spring 2007 refueling outage for North Anna Unit 2 and during the fall 2007 refueling outage for North Anna Unit 1. This schedule is necessary to meet the required implementation schedule for GSI-191/GL 2004-02 resolution. A staggered implementation of the TS change is required due to the plant modifications, which only can be performed during a plant outage. However, it is Dominion's intention to implement the North Anna Units 1 and 2 containment analyses with the GOTHIC code (replacing the Stone and Webster LOCTIC computer code) for both units during the spring North Anna Unit 2 refueling outage. Attachment 1 includes GOTHIC analyses for the current and proposed plant configurations. The current configuration analyses will be applicable to North Anna Units 1 and 2 upon NRC approval of the application of the GOTHIC methodology for North Anna.

Dominion has evaluated the proposed change and has determined that it does not involve a significant hazards consideration as defined in 10 CFR 50.92. Dominion has also determined that operation with the proposed change will not result in a significant increase in the amount of effluents that may be released offsite or in a significant increase in individual or cumulative occupational radiation exposure. Therefore, the proposed amendment is eligible for categorical exclusion as set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment is needed in connection with the approval of the proposed change. The basis for these determinations is provided in Attachment 1.

The proposed changes have been reviewed and approved by the Station Nuclear Safety and Operating Committee.

If you have any questions regarding this submittal, please contact Mr. Thomas Shaub at (804) 273-2763.

Very truly yours,

Gearld T. Bischof
Vice President – Nuclear Engineering

Commitments made in this letter: None

Attachments: (5)

Attachment 1 – Discussion of Changes
Attachment 2 – Marked-up Technical Specification Pages
Attachment 3 – Proposed Technical Specifications Pages
Attachment 4 – Marked-up Technical Specification Bases Pages
Attachment 5 – Typed Technical Specifications Pages

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COMMONWEALTH OF VIRGINIA)
)
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The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Gerald T. Bischof, who is Vice President – Nuclear Engineering, of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me the 3rd day of October, 2006.

My Commission Expires: May 31, 2010

Vicki L. Hull
Notary Public

(SEAL)

ATTACHMENT 1

PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

DISCUSSION OF CHANGES

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2

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List of Acronyms and Abbreviations

ADF	Atmospheric Dispersion Factor
AFW	Auxiliary Feedwater
AST	Alternate Source Term
CDA	Consequence Depressurization Actuation
CDT	Containment Depressurization Time
COT	Channel Operational Test
DEHLG	Double Ended Hot Leg Guillotine
DEPSG	Double Ended Pump Suction Guillotine
DER	Double Ended Rupture
DLM	Diffusion Layer Model
DPP	Depressurization Peak Pressure
EAB	Exclusion Area Boundary
ECCS	Emergency Core Cooling System
EQ	Equipment Qualification
ESF	Engineered Safety Features
ESFAS	Engineered Safety Features Actuation System
HHSI	High Head Safety Injection
IRS	Inside Recirculation Spray
LHSI	Low Head Safety Injection
LOCA	Loss of Coolant Accident
MSLB	Main Steam Line Break
NAPS	North Anna Power Station
NPSHa	Available Net Positive Suction Head
NRC	Nuclear Regulatory Commission
NSSS	Nuclear Steam Supply System
ORS	Outside Recirculation Spray
PCT	Peak Clad Temperature
PWR	Pressurized Water Reactor
QS	Quench Spray
RCS	Reactor Coolant System
RMT	Recirculation Mode Transfer
RS	Recirculation Spray
RSHX	Recirculation Spray Heat Exchanger
RWST	Refueling Water Storage Tank
SBLOCA	Small Break LOCA
SG	Steam Generator
SI	Safety Injection
SRP	Standard Review Plan
SW	Service Water
TS	Technical Specifications
UFSAR	Updated Final Safety Analysis Report

1.0 Introduction

Pursuant to 10 CFR 50.90, Virginia Electric and Power Company (Dominion) requests an amendment to Facility Operating License Numbers NPF-4 and NPF-7 in the form of changes to the Technical Specifications (TS) for North Anna Power Station Units 1 and 2 and the current approved containment analysis methodology.

This report documents the implementation of changes to the North Anna Power Station (NAPS) plant safety analyses to support the resolution of NRC Generic Letter 2004-02 [1]. Section 2 describes the changes to the plant licensing bases that are necessary to support the containment sump strainer replacement project. Section 3 summarizes the GOTHIC containment analyses using the methodology in topical report DOM-NAF-3 [3, 27]. GOTHIC analyses were performed for both the current plant configuration and a "proposed configuration" that includes changes described in Sections 2.2 (RS pump start using RWST level), 2.3 (increase to containment air partial pressure limits), 2.4 (reduction in maximum containment temperature limit), and 2.5 (change in setpoint for automatic recirculation mode transfer (RMT) for the safety injection system). The GOTHIC analyses represent a change to a UFSAR method of evaluation, as defined in 10CFR50.59, for NAPS. The NRC approved DOM-NAF-3 in Reference 27. Section 4 documents revisions to the LOCA Alternate Source Term (AST) analysis that are required to support the delayed start of the RS pumps and the increase to the containment air partial pressure limits. Section 2.6 describes the licensing basis changes. Section 5 documents the conclusions of the GOTHIC and LOCA AST analyses. References are listed in Section 6. Section 7 documents the Regulatory Evaluation and Section 8 documents the Environmental Assessment.

The proposed changes qualify for categorical exclusion for an environmental assessment as set forth in 10 CFR 51.22(c)(9). Therefore, no environmental impact statement or environmental assessment is needed in connection with the approval of the proposed change.

2.0 Description of Changes

Changes to the North Anna Power Station (NAPS) licensing bases and Technical Specifications (TS) are proposed to support resolution of NRC Generic Letter 2004-02 [1]. In a letter dated September 1, 2005, Dominion (Virginia Electric and Power Company) included three commitments for NAPS (numbers 6-8 in Attachment 6) to resolve NRC GL 2004-02 [2]. The commitments are repeated with a brief discussion about how each is resolved in this report.

- *Dominion will report the minimum NPSH margin in the NAPS-plant-specific LAR described in Item 2(e).*

  Table 3.11-1 summarizes the minimum NPSH available for the low head safety injection (LHSI), inside recirculation spray (IRS), and outside recirculation spray (ORS) pumps using the GOTHIC containment analysis methodology described in DOM-NAF-3. NPSH margins are reported for two sets of analyses that are described in Section 3. The "proposed configuration" NPSH margins (available NPSH - required NPSH) are the design values for the containment sump strainer project.

- *Dominion will submit the GOTHIC containment analysis methodology with plant-specific analyses that support the proposed changes to TS Figure 3.6.4-1 and the RS pump start method in February 2006.*

  The GOTHIC containment analysis methodology was submitted to the NRC as topical report DOM-NAF-3 [3] in a letter dated November 1, 2005 [4]. A supplement to DOM-NAF-3 was submitted in a letter dated July 14, 2006 [17]. The NRC issued the Safety Evaluation Report for DOM-NAF-3 on August 30, 2006 [27]. The containment analyses in Section 3 apply the DOM-NAF-3 methodology without modification to demonstrate compliance with containment design criteria. The proposed change to start the RS pumps using RWST level is described in Section 2.2. The proposed change to TS Figure 3.6.4-1 is described in Section 2.3.

- *The planned changes to delay the RS pumps and to modify TS Figure 3.6.4-1 require a relaxation of the currently approved containment leakage assumptions for NAPS. Dominion will submit a revised AST LOCA analysis for NAPS for NRC review in February 2006.*

  Section 3 describes how the GOTHIC LOCA containment analyses for the proposed plant configuration are subatmospheric within one hour but the containment pressure exceeds 0.5 psig during hours 1-4 but is less than 2.0 psig during hours 1-6 and is subatmospheric within 6 hours. The current NRC-approved containment leakage assumption in the LOCA Alternate Source Term (AST) analysis corresponds to a containment pressure of 0.5 psig during hours 1-4. Section 2.6 describes the changes to increase the allowable containment leakage to 2.0 psig during the time interval from 1 to 6 hours after the LOCA initiation.

Since our September 1, 2005 letter, Dominion has identified additional license amendments that are required to resolve NRC GL 2004-02. These license amendments are detailed later in Section 2:

- Change TS maximum limit for containment temperature;
- Change TS allowable values for safety injection (SI) automatic recirculation mode transfer (RMT); and
- Change TS surveillance requirements for the containment sump to be consistent with the planned design for separate strainers for the SI and RS systems.
- Change TS 5.5.15 value for Pa, the peak calculated containment pressure from a LOCA, based on the GOTHIC containment analyses in Section 3.3.

The affected TS Bases will be changed to be consistent with the TS changes and the revised safety analyses. TS Bases changes, reflecting the proposed change with the Technical Specification change discussed above, are included for information only. The TS Bases will be revised in accordance with the TS Bases Control Program, TS 5.5.13 following NRC approval of the license amendment.

2.1 Implement GOTHIC Containment Analysis Methodology

The current licensing basis analysis methodology for loss of coolant accident (LOCA) containment response is the Stone & Webster LOCTIC computer code that is described in NAPS UFSAR Chapter 6 [5]. The LOCTIC methodology will be replaced with the GOTHIC analytical methodology that is described in topical report DOM-NAF-3 [3]. The topical report was submitted to the NRC for review and approval on November 1, 2005 [4], with a supplement submitted to the NRC on July 14, 2006 [17], in advance of this license amendment request. The NRC Safety Evaluation Report for DOM-NAF-3 was issued on August 30, 2006 [27]. The GOTHIC design analyses summarized in this report have used the topical report methodology without modification and consistent with Reference 27. The GOTHIC analyses in Section 3 replace the LOCTIC analyses in NAPS UFSAR Chapter 6 for calculation of the following containment design requirements:

1. LOCA peak containment pressure and temperature,
2. LOCA containment depressurization time,
3. LOCA containment peak pressure following depressurization,
4. Available net positive suction head (NPSHa) for the LHSI pumps,
5. NPSHa for the ORS and IRS pumps, and
6. Main steam line break (MSLB) peak containment pressure and temperature

GOTHIC is used to verify that the containment liner temperature is less than the limit using the methodology in Section 3.3.3 of DOM-NAF-3 for LOCA and MSLB events. GOTHIC also can be used to verify equipment temperatures within design limits using the methodology in Section 3.3.4 of DOM-NAF-3. Finally, the minimum containment water level and maximum sump liquid temperatures from GOTHIC NPSH calculations will be used to establish bounding inputs to the sump strainer design. The GOTHIC NPSH analysis methodology in Section 3.8 of DOM-NAF-3 ensures a conservative prediction of minimum containment water level (i.e., accounting for water holdup) and maximum sump liquid temperature. Depressurization analyses are biased to maximize the total pressure and provide a conservative minimum sump water temperature. In conclusion, the GOTHIC methodology for long-term analysis of NPSH and containment depressurization ensures conservative results for component design (e.g., strainer debris head loss and component stress analyses).

2.2 Start RS Pumps on RWST Level Low Coincident with High High Containment Pressure

NAPS is a three-loop Westinghouse PWR with a subatmospheric containment design. The following plant description is consistent with Chapter 6 of the NAPS UFSAR. The engineered safety features (ESF) that mitigate a LOCA or MSLB event include:

- A safety injection (SI) system that injects borated water into the cold legs of all three reactor coolant loops for the entire spectrum of reactor coolant system (RCS) break sizes to limit core temperature, maintain core integrity, and provide negative reactivity for additional shutdown capability.

- Two separate low-head safety injection (LHSI) subsystems, either of which provides long-term removal of decay heat from the reactor core.

- Two separate subsystems of the containment depressurization system—quench spray (QS) and recirculation spray (RS)—that operate together to reduce the containment temperature, return the containment pressure to subatmospheric, and remove heat from the containment. The RS subsystem maintains the containment subatmospheric and transfers heat from the containment to the service water (SW) system.

The QS system consists of two pumps that start on a Containment Depressurization Actuation (CDA) High High containment pressure signal and draw suction from the refueling water storage tank (RWST) until the tank is empty. The RS system consists of four independent trains, each with one pump that takes suction from the containment sump. Two inside recirculation spray (IRS) pumps are located inside the containment sump, while two outside recirculation spray (ORS) pumps are located in the Safeguards Building. Currently, the RS pumps are started using delay timers that are initiated on the CDA signal. Each RS train has a recirculation spray heat exchanger (RSHX) that is cooled by SW (on the tube side) for long-term containment heat removal. The casing cooling subsystem includes two pumps that start on a CDA signal and take suction from the casing cooling tank. Each casing cooling pump discharges cold water to the suction of its respective ORS pump to increase the available NPSH. The SI system consists of two LHSI pumps and three HHSI pumps that draw from the RWST and inject into the RCS cold legs. The SI pumps take suction from the RWST until a low-low level is reached, at which time recirculation mode transfer (RMT) occurs. The RMT function changes the LHSI pump suction from the RWST to the containment sump and the HHSI pump suction from the RWST to the discharge header of the LHSI pumps.

Because the RS and SI systems use the containment sump to demonstrate that design criteria are satisfied, the resolution of NRC Generic Letter 2004-02 affects the IRS, ORS and LHSI pumps. Section 3.7.2.3.2.4 of NEI-04-07 [6] has different requirements for demonstrating adequate pump performance whether the sump strainer is fully or partially submerged when the LHSI and RS pumps are operating. For a fully submerged strainer, the strainer debris head loss must be less than or equal to the NPSH margin. For a partially submerged strainer, the strainer debris head loss must be less than one-half the pool height. Thus, if the strainer submergence height is only 1.0 ft at pump start, then the allowable debris head loss is 0.5 ft. Further, only the wetted strainer surface area can be credited, and these limitations together could impose a very large strainer footprint.

Currently, the NAPS RS pumps start using delay timers that are initiated when the containment pressure reaches the CDA High High containment pressure setpoint. The IRS pumps have a 400-second setpoint and the ORS pumps have a 210-second setpoint. At these start times, the containment water level is predicted to be less than 1 ft in the current UFSAR containment analyses. While there is sufficient NPSH margin for the pumps, the current timer delay setpoints start the RS pumps when the sump strainer is partially submerged. Because the partial submergence requirement may be too restrictive for the sump strainer design, the RS pump start will be delayed until sufficient water level is available in the containment.

Proposed Modification

NAPS proposes to start the IRS and ORS pumps on 60% RWST wide range (WR) level coincident with a CDA High High containment pressure signal. The ORS pumps will receive an immediate start signal once the coincidence logic is satisfied. The IRS pumps will start using a 120-second delay timer from the coincident actuation signal. This delay will minimize the impact on emergency diesel generator loading and allow for the ORS system to fill its piping completely, deliver spray to the containment, and reach a stable flow demand on the sump before the IRS pumps start. This method of starting the RS pumps ensures that a reliable mass of liquid has been added to the containment to meet the sump strainer submergence requirements for the range of LOCA break sizes that require the containment sump. The use of RWST WR level to start the RS pumps classifies the new instrumentation as part of the Engineered Safety Features Actuation System (ESFAS). Thus, the design will include safety-grade instrumentation consistent with UFSAR Section 7.3, "Engineered Safety Features Actuation System" with allowable values and surveillances that must be added to the NAPS Technical Specifications [7].

Plant Safety Analysis Impact

Delaying the start method of the RS pumps has a potential adverse impact on several design criteria, including LOCA and MSLB containment pressure and temperature, environmental conditions for safety-related equipment inside containment, diesel loading, and dose consequences analyses. The following impacts on the NAPS UFSAR safety analyses and design were evaluated.

- Less energy is removed from the containment sump liquid before the LHSI pumps take suction from the containment sump, causing a decrease in NPSHa for the LHSI pumps. The LHSI pump NPSHa analysis determines the lowest acceptable RWST water level setpoint for RS pump initiation. Section 3.6 demonstrates that the LHSI pumps have sufficient NPSH margin with the proposed change to start the IRS and ORS pumps on 60% RWST WR level, provided that other changes are made to offset the LHSI pump NPSH margin reduction from delaying the RS pump start. Specifically, the safety analyses require an increase in containment air pressure, a change to the RMT actuation setpoint, and a reduced containment temperature operating limit of 115 F.

- The LOCA and MSLB containment pressures and temperatures are higher during the period when only the QS system is delivering spray flow to containment. The GOTHIC analyses in Sections 3.3 and 3.4 show the LOCA containment pressure and temperature decreasing before the ORS pumps start at approximately 30 minutes (assuming 1 train of ESF), and the RS pump start increases the depressurization rate. The delayed RS pump start increases the containment depressurization time to subatmospheric conditions. Section 3.4 demonstrates that the containment pressure after a LOCA is less than 2.0 psig within one hour and less than 0.0 psig within 6 hours. The current LOCA dose consequences analysis assumes a containment leak rate at the TS 5.5.15 limit of 0.1% of containment volume per day for the first hour of the accident, a conservative leak rate corresponding to 0.5 psig containment pressure for the time interval from 1 to 4 hours, and no leakage after 4 hours (i.e., containment pressure is subatmospheric) [20, Section 3.1.1.3]. The proposed changes create containment pressure responses that are not bounded by the current AST analysis assumption for containment leakage. Thus, Section 2.6 describes LOCA AST analyses that increase the containment leak rate during the time interval from 1 to 6 hours to a value that corresponds to a containment pressure of 2.0 psig. The GOTHIC analyses in Section 3.7 show the MSLB containment pressure and temperature without any credit for the RS system. The QS pump is the lone spray pump running against a SG boiloff rate of the maximum AFW flow rate. Containment pressure and temperature increase to a peak at 30 minutes when the AFW flow to the faulted SG is terminated, after which the pressure and temperature decrease based on the cooling capacity of the QS pump.

- The delayed RS pump start creates more adverse pressure and temperature conditions for the operation of safety-related equipment inside containment. The GOTHIC analyses in Section 3 created LOCA and MSLB containment pressure and temperature profiles based on the proposed change to the RS pump start. Various break locations, break sizes, and single-failures were considered. Section 3.9 concludes that the GOTHIC profiles remain bounded by existing equipment qualification test temperature and pressure data or are acceptable by evaluation. Therefore, the operation of safety-related equipment inside containment during a LOCA or MSLB is not affected adversely by the proposed change to delay starting the RS pumps.

- Starting the RS pumps later can reduce the removal of iodine from the containment atmosphere and potentially increase the release of iodine to the environment during the period when RS is not operating. The current LOCA AST basis starts to credit iodine removal when outside RS pumps start at 289 seconds. Section 2.6 documents a change to the LOCA AST bases to credit iodine removal from the RS system at 40 minutes post-LOCA.

- Currently, the RS pumps start using time delays from the CDA actuation signal (210 seconds for ORS and 400 seconds for IRS). Using 60% RWST WR level coincident with High High containment pressure delays the RS pump start until at least 14 minutes after accident initiation. This pump start delay reduces the early loads on the emergency diesel generator. The ORS pumps will receive an immediate start signal once the coincidence logic is satisfied. The IRS pumps will start using a 120-second delay timer from the coincident actuation signal. This delay is sufficient to avoid simultaneous starting of the RS pumps on the same emergency diesel generator. Thus, the proposed change does not have an adverse impact on emergency diesel generator capability.

- The NPSHa for the RS pumps increases. Section 3.6 demonstrates how the ORS and IRS pumps have more NPSH margin from higher containment water levels and subcooling of the sump water by casing cooling and bleed flow from the QS system that injects at the IRS pump suctions.

Sections 3 and 4 of this report demonstrate that the NAPS safety analyses satisfy the accident analysis acceptance criteria and other design requirements when the RS pumps are started on 60% RWST WR level coincident with a High High containment pressure, provided that other changes are made to the containment air partial pressure operating limits (Section 3.10), maximum containment temperature limit, and SI automatic recirculation mode transfer setpoint to provide sufficient NPSH margin.

<u>Changes to NAPS Technical Specifications</u>
The use of RWST WR level to start the RS pumps classifies the new instrumentation as part of the ESFAS. The allowable values and surveillances for the ESFAS function must be added to the NAPS Technical Specifications [7]. The signals from the RWST WR level channels are used to initiate RMT for the safety injection system. Three of the level channels will be used for the RS pump start circuitry. RMT occurs when RWST WR level reaches a "Low Low" setpoint according to TS 3.3.2. Since the RWST level setpoint for initiation of the RS pumps will be a higher value (60%) than the proposed RMT setpoint (16.0%), the RS pump initiation function will use the term "RWST Level Low".

The RWST Level Low trip will be designed to de-energize to actuate. The RS pump start will depend on a coincidence of 60% RWST WR level with Containment Pressure High High (which is 2-out-of-4 channels energize to actuate), so a spurious de-energization of the RWST level circuits would not cause an unnecessary start of the RS pumps. TS 3.6.7 requires the RS system to be operable in Modes 1 through 4, but automatic system actuation is only required to be operable in Modes 1, 2 and 3 per TS 3.3.2. The RWST Level Low channels shall be operable in Modes 1 through 3 to be consistent with the Containment Pressure High-High channels (TS 3.3.2 Function 2.c). The RWST Level Low trip will actuate from 2-out-of-3 channels and 1-out-of-2 trains. The 2-out-of-3 logic configuration is consistent with other ESFAS circuits that de-energize to actuate at North Anna. The proposed change to TS 3.3.2 requires an inoperable channel to be placed in trip, leaving a 1-out-of-2 configuration that satisfies redundancy requirements. Condition D in TS 3.3.2 specifies the required actions for an inoperable channel for an ESFAS function that is required in MODES 1, 2, and 3 and is selected for the RWST Level Low channels. The surveillance requirements identified in the TS changes are consistent with the requirements for the SI RMT instrumentation (ESFAS Function 7.b). The site-specific PRA analysis was reviewed to confirm that the signal unavailability and risk impacts from the proposed RWST Level Low channels surveillance frequencies and completion times are consistent with those evaluated in WCAP-14333-P-A [26] and approved by the NRC.

Manual initiation of recirculation spray is required in Mode 4, even though automatic actuation is not required. In Mode 4, adequate time is available to manually actuate required components in the event of a DBA. However, because of the large number of components actuated on a CDA, actuation is simplified by the use of the manual actuation switches (ESFAS Function 2.a in TS 3.3.2). To be consistent with ESFAS function 2.b for containment spray, the automatic actuation logic and actuation relays for RWST Level Low shall be operable in Mode 4.

The determination of TS Allowable Values for the NAPS RWST Level Low initiation used Method 1 in ISA-RP67.04.02-2000 [20]. There are two Analytical Limits and thus two Allowable Values associated with this new function. The Analytical Limits are ≥ 57.50 % WR Level and ≤ 62.50 % WR Level. The corresponding Allowable Values are ≥ 59.00 % WR Level and ≤ 61.00 % WR Level from the following analysis. The reader is referred to Figure 2.1-1 for the relationship between the Analytical Limits and the Allowable Values.

Adding the Total Loop Uncertainty to the Analytical Limit yields a Minimum Trip Setpoint of 59.24 % WR Level. Adding the Non-COT (Channel Operational Test) error components to the Analytical Limit yields a Minimum Allowable Value of 58.868 % WR Level. The Actual Nominal Trip Setpoint of 60.00 % WR Level is conservative with respect to the Minimum Trip Setpoint. The Actual Allowable Value of ≥ 59.00 % WR Level is conservative with respect to the Minimum Allowable Value. The Allowable Value of ≥ 59.00 % WR Level is based on maintaining a Nominal Trip Setpoint value of 60.00 % WR Level. The proposed Allowable Value of ≥ 59.00 % WR Level is conservative with respect to the calculated value using rack error terms (i.e., COT error terms).

Subtracting the Total Loop Uncertainty from the Analytical Limit yields a Maximum Trip Setpoint of 60.885 % WR Level. Subtracting the Non-COT error components from the Analytical Limit yields a Maximum Allowable Value of 61.26 % WR Level. The Actual Nominal Trip Setpoint of 60.00 % WR Level is conservative with respect to the Maximum Trip Setpoint. The Actual Allowable Value of ≤ 61.00% WR Level is conservative with respect to the Maximum Allowable Value. This Allowable Value of ≤ 61.00 % WR Level is based on maintaining a Nominal Trip Setpoint value of 60.00 % WR Level. The proposed Allowable Value of ≤ 61.00 % WR Level is conservative with respect to the calculated value using rack error terms (i.e., COT error terms).

The statistical combination of the COT and Non-COT error components is provided below and used in Figure 2.1-1 to determine the Minimum/Maximum Trip Setpoints and the Minimum/Maximum Allowable Values.

$Non\text{-}COT_{error} = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA+SMTE)^2 + SD^2 + SPE^2 + STE^2 + SPSE^2 + M1MTE^2 + M3MTE^2 + RTE^2]^{1/2}$

$Non\text{-}COT_{error} = 0.064 \pm [0.0^2 + 0.022^2 + 0.0^2 + (0.5+0.211)^2 + 0.222^2 + 0.0^2 + 0.933^2 + 0.0^2 + 0.153^2 + 0.03^2 + 0.5^2]^{1/2}$

$Non\text{-}COT_{error} = + 1.368$ % of span and $- 1.24$ % of span

$COT_{error} = \pm (M1^2 + M3^2 + RD^2)^{1/2}$

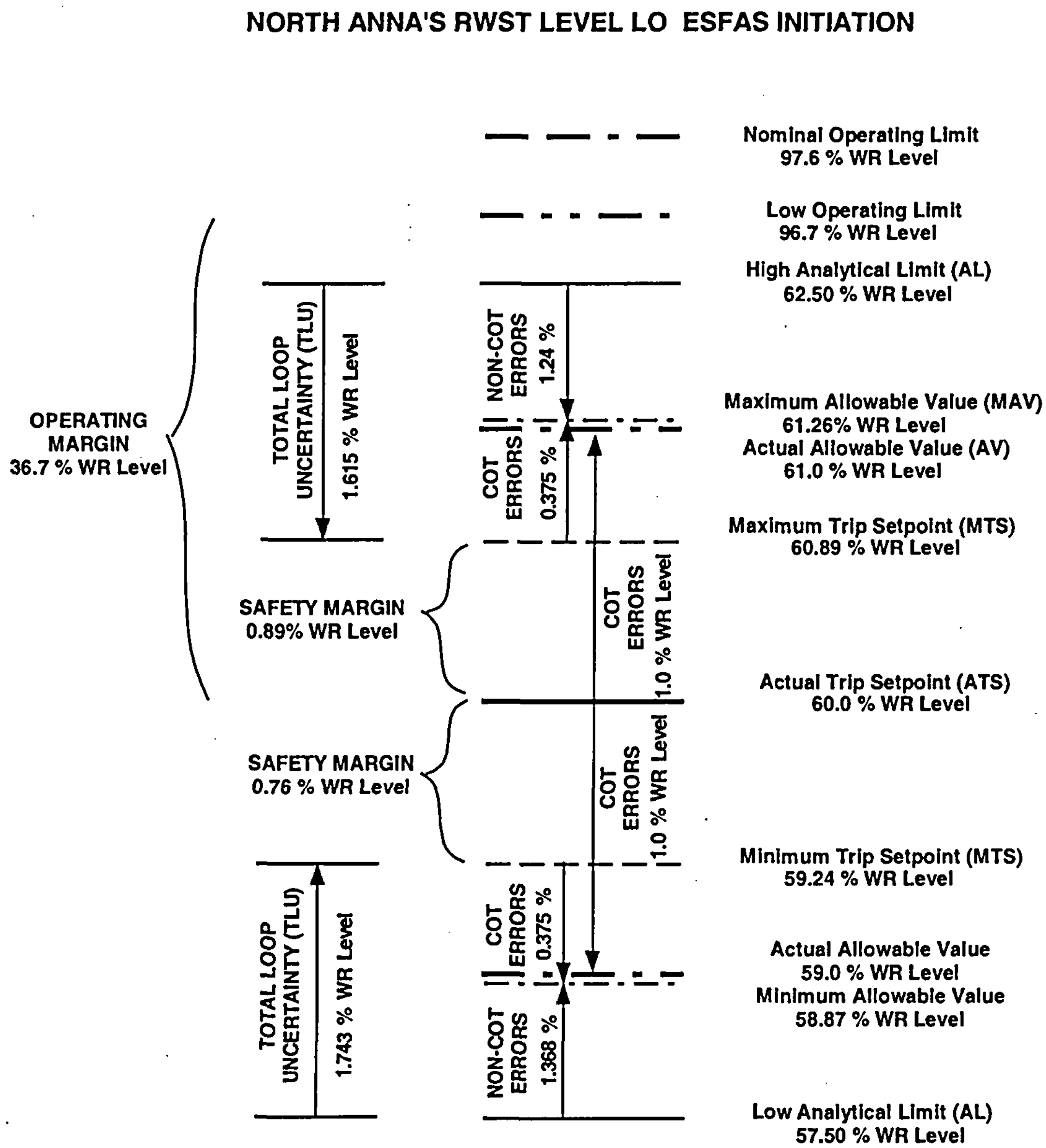
$COT_{error} = \pm (0.1^2 + 0.25^2 + 1.0^2)^{1/2}$

$COT_{error} = \pm 1.036$ % of span

Based on the above evaluations, the following changes to the NAPS Technical Specifications are proposed for implementation of the RWST Level Low instrumentation to start the IRS and ORS pumps on 60% RWST WR level coincident with High High containment pressure:

- TS Table 3.3-2: Add the RWST Level Low Coincident with High High Containment Pressure as ESFAS Function 2.d with the requirement for 2-out-of-3 channels to trip and 1-out-of-2 ESFAS trains to trip. The ESFAS logic is required in Modes 1, 2 and 3 consistent with the requirements for Containment Pressure High-High (ESFAS Function 2.c). Condition D is selected for the RWST Level Low channels and Condition C applies to the Automatic Actuation Logic and Actuation Relays (ESFAS Function 2.b). RWST Level Low coincident with High High Containment Pressure has Allowable Values of $\geq$ 59% and $\leq$ 61% WR level.

Figure 2.1-1: North Anna RWST Level Low ESFAS Initiation



Note: The COT errors are based on the Minimum Trip Setpoint value minus the Minimum Allowable value and the Actual Trip Setpoint value minus the Actual Allowable Value.

2.3 Change Containment Air Partial Pressure Operating Limits in TS Figure 3.6.4-1

The GOTHIC containment analyses for LOCA containment peak pressure (Section 3.2), MSLB containment peak pressure (Section 3.7), and LOCA containment depressurization (Section 3.4) support an increase in the containment air partial pressure upper limit in TS Figure 3.6.4-1. The proposed TS upper limit is 12.3 psia from 35 F to 55 F SW temperature, linearly decreasing to 10.4 psia at 95 F. The TS lower limit will be increased to a constant 10.3 psia to recover LHSI pump NPSH margin that has been reduced by the delayed RS pump start. The proposed change to TS Figure 3.6.4-1 and the technical basis for the upper and lower limits are presented in Section 3.10 of this report.

The combined increase to the air partial pressure limits and the delayed start of the RS pumps create analyzed containment pressures that are greater than 0.0 psig after 1 hour for double-ended pump suction guillotine (DEPSG) breaks with one train of emergency safety features. Section 3.4 shows the DEPSG break proposed configuration analyses produce a containment pressure that is greater than 0.0 psig but less than 2.0 psig during the interval from 1 to 6 hours after the event initiation. The GOTHIC analyses predict containment pressures that are less than 0.0 psig after 6 hours. To accommodate the increased containment pressure profiles, the containment leakage in the LOCA dose consequences analysis was increased to correspond to 2.0 psig during the interval from 1 to 6 hours (see Section 2.6). As a result, the affected TS Bases are changed from the current analyzed pressure of 0.5 psig from 1 to 4 hours to 2.0 psig from 1 to 6 hours after the LOCA.

2.4 Change Maximum Limit for Containment Temperature

Currently, the containment average temperature is limited to 120 F by TS 3.6.5 and TS Figure 3.6.4-1. The maximum containment temperature is a limiting initial condition for several of the LOCA and MSLB analyses, as shown in Table 3.11-2. North Anna proposes to reduce the TS maximum temperature limit from 120 F to 115 F to recover design margin. With a lower initial containment temperature, the passive heat sinks can condense more steam in the early phases of a LOCA or MSLB event, generating lower pressures in containment. For long-term analyses, a lower initial containment temperature reduces the amount of initial stored energy in the containment passive heat sinks that is eventually passed to the containment atmosphere, quenched by spray flow, and added to the containment sump. Thus, the long-term NPSH analyses see a small benefit. The proposed reduction in the TS containment temperature limit does not create a burden on the plant, as containment average temperatures typically are less than 105 F.

2.5 Change Automatic RMT Setpoint

North Anna proposes to change the safety injection automatic recirculation mode transfer (RMT) setpoint from 19.4 % to 16.0 % RWST wide range level. The purpose of the change is to delay the time of RMT so that the RS system can remove more energy from the containment and reduce the sump temperature before the LHSI pumps swap suction from the RWST to the containment sump. Delaying RMT also provides a higher containment water level before LHSI swapover to recirculation. The lower sump temperature and higher water level increase the NPSH margin for the LHSI pumps at RMT. The containment analyses in Section 3 reflect the change and include a 2.5 % uncertainty on the RMT setpoint. The current configuration analyses assume a range of 16.9-21.9 % WR level, while the proposed configuration analyses assume a range of 13.5-18.5 % WR level. For the LHSI pump NPSH analyses in Section 3.6, the setpoint change increases the RMT initiation time by 212 seconds for the cases analyzed at 95 F SW. The proposed setpoint of 16.0 % WR level provides sufficient time to complete the automatic valve manipulations with margin to preclude air entrainment in the SI piping system.

<u>Changes to NAPS Technical Specifications</u>

The SI RMT function occurs when RWST level reaches the "RWST Level Low-Low" setpoint. The current plant setpoint is 19.4 % WR level and the TS Allowable Values are $\geq$ 18.4 % and $\leq$ 20.4 % in TS Table 3.3.2-1. The determination of TS Allowable Values for the NAPS RWST Level Low-Low initiation used Method 1 in ISA-RP67.04.02-2000 [20]. There are two Analytical Limits and thus two Allowable Values associated with this new function. The Analytical Limits are $\geq$ 13.50 % WR Level and $\leq$ 18.50 % WR Level. The corresponding Allowable Values are $\geq$ 15.00 % WR Level and $\leq$ 17.00 % WR Level from the following analysis. The reader is referred to Figure 2.1-2 for the relationship between the Analytical Limits and the Allowable Values.

Adding the Total Loop Uncertainty to the Analytical Limit yields a Minimum Trip Setpoint of 15.243 % WR Level. Adding the Non-COT (Channel Operational Test) error components to the Analytical Limit yields a Minimum Allowable Value of 14.868 % WR Level. The Actual Nominal Trip Setpoint of 16.00 % WR Level is conservative with respect to the Minimum Trip Setpoint. The Actual Allowable Value of $\geq$ 15.00 % WR Level is conservative with respect to the Minimum Allowable Value. The Allowable Value of $\geq$ 15.00 % WR Level is based on maintaining a Nominal Trip Setpoint value of 16.00 % WR Level. The proposed Allowable Value of $\geq$ 15.00 % WR Level is conservative with respect to the calculated value using rack error terms (i.e., COT error terms).

Subtracting the Total Loop Uncertainty from the Analytical Limit yields a Maximum Trip Setpoint of 16.885 % WR Level. Subtracting the Non-COT error components from the Analytical Limit yields a Maximum Allowable Value of 17.26 % WR Level. The Actual Nominal Trip Setpoint of 16.00 % WR Level is conservative with respect to the Maximum Trip Setpoint. The Actual Allowable Value of $\leq$ 17.00% WR Level is conservative with respect to the Maximum Allowable Value. This Allowable Value of $\leq$ 17.00 % WR Level is based on maintaining a Nominal Trip Setpoint value of 16.00 % WR Level. The proposed Allowable Value of $\leq$ 17.00 % WR Level is conservative with respect to the calculated value using rack error terms (i.e., COT error terms).

The statistical combination of the COT and Non-COT error components is provided below and used in Figure 2.1-2 to determine the Minimum/Maximum Trip Setpoints and the Minimum/Maximum Allowable Values.

$$\text{Non-COT}_{\text{error}} = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA+SMTE)^2 + SD^2 + SPE^2 + STE^2 + SPSE^2 + M1MTE^2 + M3MTE^2 + RTE^2]^{1/2}$$

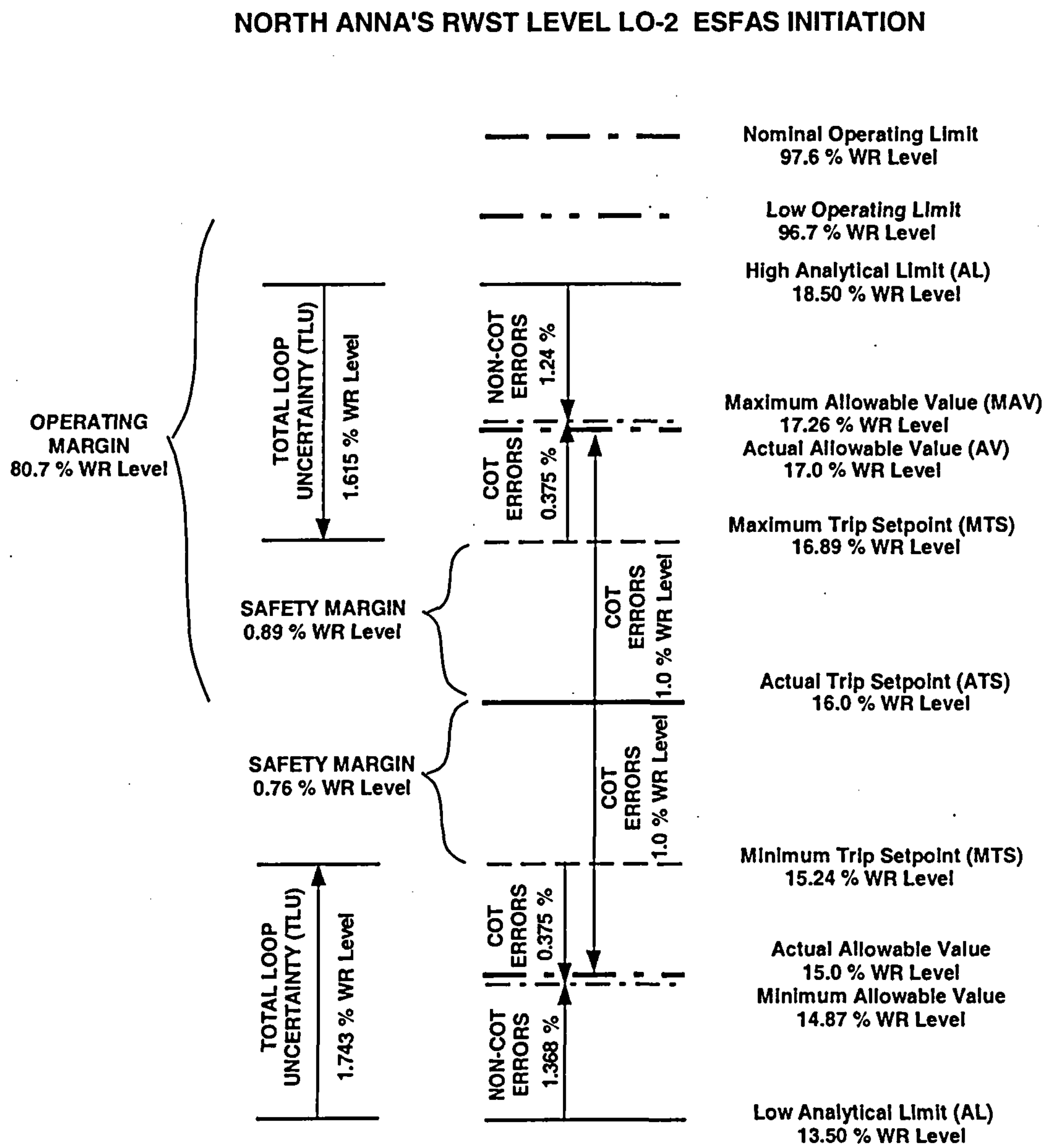
$$\text{Non-COT}_{\text{error}} = 0.064 \pm [0.0^2 + 0.022^2 + 0.0^2 + (0.5+0.211)^2 + 0.222^2 + 0.0^2 + 0.933^2 + 0.0^2 + 0.153^2 + 0.03^2 + 0.5^2]^{1/2}$$

$$\text{Non-COT}_{\text{error}} = +\ 1.368\ \%\ \text{of span and} - 1.24\ \%\ \text{of span}$$

$$\text{COT}_{\text{error}} = \pm (M1^2 + M3^2 + RD^2)^{1/2}$$
$$\text{COT}_{\text{error}} = \pm (0.1^2 + 0.25^2 + 1.0^2)^{1/2}$$
$$\text{COT}_{\text{error}} = \pm\ 1.036\ \%\ \text{of span}$$

Based on the above evaluations and the safety analyses in Section 3, it is proposed to change the NAPS Technical Specifications RWST Level Low-Low function Allowable Values to $\geq$ 15% and $\leq$ 17% RWST WR level.

Figure 2.1-2: North Anna RWST Level Low-Low ESFAS Initiation



Note: The COT errors are based on the Minimum Trip Setpoint value minus the Minimum Allowable value and the Actual Trip Setpoint value minus the Actual Allowable Value.

2.6 LOCA Alternate Source Term

Delaying the RS pump start will result in a short-term increase in air leakage from the containment and a short-term reduction in spray removal of radioactive isotopes from the containment atmosphere. To reflect the delay of the RS pump start, the following changes to the LOCA AST analysis are proposed:

1) Delay in RS operation for spray removal from 288.5 seconds to 40 minutes.
2) Spray volume for QS only operation, combined QS/RS operation, and RS only operation versus 1 sprayed volume for entire period of spray operation.
3) Early ORS pump start at 14 minutes for ECCS leakage vs. 288.5 seconds in the current basis.
4) RWST backleakage is assumed to start at 31.8 minutes vs. 30 minutes in the current basis.
5) Containment leakage after the first hour of a LOCA has increased to 0.04%-volume-per-day for the time period 1 to 6 hours vs. 0.021 %-volume-per-day for the time period 1 to 4 hours in the current analysis.
6) Changes in aerosol removal coefficients due to the delay in RS operation and conservative QS flow rate assumptions.
7) Variable containment sump volume based on the containment analysis.

Other changes were made to the AST LOCA analysis to either remove conservative assumptions existing in the current analysis or changes based on a reanalysis of other parameters. These changes include:

1) Taking credit for the 96-hour to 720-hour control room occupancy factor listed in Regulatory Guide (RG) 1.183.
2) Taking credit for the timed release of nuclides into the containment sump in accordance with RG 1.183.
3) Increase the Decontamination Factor (DF) for releases from the RWST from 10 to 40.
4) For conservatism the containment volume has been increased to 1.916E+06 ft^3.
5) Increase the auxiliary building filter efficiency for organic iodines from 70% to 90% to be consistent with the Technical Specifications.
6) Increase the control room filter efficiency for organic iodines from 70% to 95% to be consistent with the Technical Specifications.
7) A slight increase in control room volume based on a recalculation.
8) The RWST "breathing rate" changed from 4 cfm to 3.7 cfm.

2.7 Containment Sump Surveillance Requirements

Currently, the NAPS containment sump is shared by the SI and RS systems to perform the design functions for long-term core cooling and containment heat removal. The TS surveillance requirement (SR) for inspecting the containment sump is included only in the SI system (TS SR 3.5.2.8). However, the replacement sump strainer system will consist of separate strainers for the SI and RS systems. Therefore, it is proposed to add a surveillance requirement for an 18-month inspection of the RS system strainer (SR 3.6.7.7). As part of this change, TS SR 3.6.7.7 is being renumbered to TS SR 3.6.7.8 to be consistent with the Improved Technical Specifications practice of ordering surveillance requirements by frequency. In addition, SR 3.5.2.8 is changed to reflect the elimination of the existing trash racks and screens and to cover all of the SI sump components.

3.0 GOTHIC Containment Analyses

GOTHIC will replace the Stone & Webster LOCTIC code as the evaluation methodology in Chapter 6 of the NAPS UFSAR for the containment design requirements described in Section 2.1. This section of the report documents two sets of GOTHIC analyses that were performed to demonstrate acceptable margins to the containment design criteria.

1. **Current Configuration:** The current RS system configuration with delay timers (400 seconds for IRS pumps, 210 seconds for ORS pumps), the current SI RMT automatic setpoint of 19.4% RWST level, the current TS 3.6.5 maximum air temperature of 120 F, and the current TS Figure 3.6.4-1 containment air partial pressure limits were used to demonstrate acceptable margins for the current plant configuration. These analyses are comparable to the LOCTIC analyses currently in the NAPS UFSAR Chapter 6. GOTHIC margin improvements with respect to LOCTIC were described in Section 4 of topical report DOM-NAF-3. While some design inputs have changed from the LOCTIC analyses (see Section 3.1.4), transient behavior and results are similar to the LOCTIC UFSAR analyses. The current configuration analyses establish a set of baseline GOTHIC analysis results to which the proposed configuration cases are compared.

2. **Proposed Configuration**: The proposed configuration assumes four changes from the first set of analyses.

   - The RS pumps are started assuming 60% RWST level coincident with a High High containment pressure signal. The ORS pumps start directly from the signal. The IRS pumps start 120 seconds after the actuation signal is reached. Instrument uncertainty is included for the level signal and the timer setpoint.

   - The SI RMT nominal setpoint is changed from 19.4% to 16% RWST WR level. Instrument uncertainty is included for the level signal. The time to complete the RMT function ranges from 95-210 seconds (same as the current configuration analyses).

   - The analyses that assume maximum containment temperature (see Table 3.11-2) revise the input from 121.5 F (current TS limit of 120 F + 1.5 F uncertainty) to 116.5 F (proposed TS limit of 115 F + 1.5 F uncertainty) for the containment air and the passive heat sinks.

   - The containment air partial pressure is increased to the values in the proposed revision to TS Figure 3.6.4-1 that is provided in Section 3.10. The TS containment air partial pressure envelope is established to provide adequate margins to the containment acceptance criteria from the NAPS UFSAR, and to the proposed containment pressure limit of 2.0 psig from 1-6 hours after the LOCA per Section 4.

The NAPS acceptance criteria for the proposed configuration containment analyses are:

- LOCA and MSLB containment peak pressure < 45 psig
- LOCA containment pressure < 2.0 psig from 1-6 hours and < 0.0 psig after 6 hours
- LOCA containment temperature < 280 F
- LHSI Pump NPSHa > Required NPSH
- ORS Pump NPSHa > Required NPSH
- IRS Pump NPSHa > Required NPSH

3.1 Application of the GOTHIC Methodology

The GOTHIC analyses employ the containment response methodology described in topical report DOM-NAF-3 [3, 4, 17, 27] without modification. Benchmarks to LOCTIC containment response analyses from the Surry UFSAR were presented in Section 4 of DOM-NAF-3 and code differences in the treatment of key phenomena were described in that report. Benchmark analyses were performed for the NAPS GOTHIC models against eight LOCTIC analyses:

1) LOCA peak containment pressure (DEHLG break);
2) LOCA containment depressurization at 38 F SW (DEPSG break, minimum ESF);
3) LOCA containment depressurization at 75 F SW (DEPSG break, minimum ESF);
4) MSLB peak containment pressure (1.4 ft^2 break at 0% power);
5) MSLB peak containment temperature (0.6 ft^2 break at 102% power);
6) LHSI pump NPSHa pressure (DEPSG break with minimum ESF and maximum SI flow);
7) IRS pump NPSHa (DEHLG break, 1 LHSI pump failure, maximum RWST temperature); and
8) ORS pump NPSHa (DEHLG break, 1 LHSI pump failure, minimum RWST temperature).

The containment response for each case was comparable to the Surry GOTHIC analyses presented in References 3, 8 and 16. The differences in response with respect to LOCTIC are also the same as reported in DOM-NAF-3, Section 4. GOTHIC predicts lower containment pressures and higher sump temperatures early in the accident. In addition, GOTHIC predicts faster containment depressurization times with margin in the post-QS peak pressure. The extensive benchmarking effort concluded that the North Anna GOTHIC models had been constructed appropriately and provided a good match to the LOCTIC (SWEC)/FROTH (Westinghouse) integral mass and energy releases to the containment for DEPSG and DEHLG breaks. Results from the benchmarking are not included in this report, because the current configuration analyses can be used to compare behavior against the LOCTIC analyses in the UFSAR. The remaining part of this section reviews the key elements of the NAPS GOTHIC models used for the containment design analyses.

3.1.1 Model Geometry

The NAPS containment is represented by a lumped control volume. The minimum and maximum free volumes are unchanged from the current analyses; the values are presented in Table 3.1-1. Control volumes are used to model the RWST and piping for the RS and SI systems. Junction elevations, heights, and loss coefficients are input consistent with the guidance in DOM-NAF-3, Section 3.2.1. Nineteen thermal conductors model the containment passive heat sinks for LOCA and MSLB analyses.

For LOCA analyses, flow paths model the break through the end of reflood using the vendor's mass and enthalpy data. At the end of reflood, the GOTHIC simplified RCS model is activated. The release from the first set of flow paths is stopped and different flow paths are activated from the RCS. For a DEPSG break, different flow paths model the release from the broken loop cold leg and the broken loop pump suction during post-reflood. For a DEHLG break, different flow paths model the broken hot leg release from the vessel and the broken hot leg connection to the steam generator. A separate flow path and boundary condition inject the accumulator nitrogen into containment for LOCAs (Section 3.2.2 in DOM-NAF-3).

3.1.2 Engineered Safety Features

The GOTHIC model includes a flow boundary condition to model the quench spray (QS) pumps. Flow is variable as a function of the RWST level and downstream pressure. Pump heat is added when conservative. Pipe fill time and pump start delays are incorporated into a delay time that passes before the QS pumps deliver flow to the spray headers. A fraction of each QS pump flow is diverted to the suction of the respective IRS pump using boundary conditions.

Each RS pump is modeled with a flow boundary condition. Constant flow rates are assumed to bound the minimum and maximum delivered flow rates calculated from system analyses. RS pump heat is added when conservative. Trips are used to start the IRS and ORS pumps in accordance with the design description in Section 2.2. The trip delays include fill times for the RS pump discharge piping and time for the pumps to start and reach full flow. Control volumes are used for the RS pump suctions to allow the mixing of bleed injection flow and the accurate calculation of NPSHa at the pump first-stage impeller. Suction friction and form losses are included in the pump suction flow paths to accurately calculate NPSH available at the pump impeller. The casing cooling subsystem is modeled with a flow boundary condition for each pump that injects water to its respective ORS pump suction volume. The casing cooling boundary conditions are stopped with a trip when the available tank volume is exhausted.

Each of the four recirculation spray lines contains a single-pass, shell-and-tube heat exchanger located inside containment between the RS pump and the spray header. Heat exchanger performance is modeled to ensure a conservative prediction of heat removal from the sump for long-term accident analysis. The RSHX model selections in GOTHIC were benchmarked to a detailed heat exchanger design code over the range of accident flow rates and temperatures in the RS and SW systems. The HX models include tube plugging and fouling for analyses where it is conservative. Benchmark analyses demonstrated that the GOTHIC RSHX heat rates are comparable to LOCTIC after the containment sump liquid temperatures converge to similar values.

Safety injection is modeled with flow boundary conditions that draw from the RWST and the containment sump. Before the end of reflood, sink boundary conditions remove mass from the RWST consistent with the vendor mass and energy calculation. At the end of reflood, the GOTHIC mass and energy model is activated and boundary conditions inject RWST water into the primary system. When the RWST reaches a low-low level, the RWST boundary conditions are terminated and another boundary condition directs water from the containment sump to the primary system.

Nozzle components are used for each spray line. The Sauter mean diameter was calculated for each spray system in accordance with DOM-NAF-3, Section 3.4.1. For containment integrity analyses, the nozzle spray flow fractions are set to 1.0 and the containment height is reduced using the methodology in Section 3.4.1.2 of DOM-NAF-3. The floor area gives the correct drop volume and surface area exposed to the containment atmosphere. For NPSH analyses, sensitivity studies showed that NPSHa is not sensitive to a reduction in containment height once the other assumptions that minimize NPSHa are implemented. Therefore, the containment height in the NPSH models is input from the containment free volume and the pool surface area.

3.1.3 Containment Passive Heat Sinks

The containment heat sinks are grouped into the following categories.

- Containment structure shell below grade
- Containment structure shell above grade
- Containment structure dome and liner
- Containment structure floor above floor liner
- Containment structure mat below floor liner
- Internal concrete slabs
- Carbon steel inside the containment
- Stainless steel inside the containment
- Accumulator tanks filled with water (MSLB only)

The DOM-NAF-3, Section 3.3, modeling guidelines for nodalizing thermal conductors were applied. The surface area and thickness for concrete structures were taken from the current UFSAR analysis basis. The metal surface area and mass were increased from the current UFSAR minimum inventory based on a comprehensive review of containment metal that concluded that the previous inventory had omitted some structural metal and components. Thermal properties for concrete and steel were obtained from an engineering handbook, are presented in Table 3.1-2, and are the same as the Surry GOTHIC application [16]. Paint thermal properties from the current LOCTIC analyses were confirmed to be conservative for the NAPS paint systems and were not changed. A contact resistance was modeled in the containment liner interface between concrete and carbon steel with a conductance of 40 Btu/hr-ft^2-F, which is more conservative than the maximum value of 100 Btu/hr-ft^2-F specified in DOM-NAF-3, Section 3.3.1.

Heat transfer options were set consistent with DOM-NAF-3, Section 3.3.2. The Direct heat transfer option with DLM condensation was applied to all containment heat sinks except the sump floor. The Split option was used for the floor to switch the heat transfer from vapor to liquid as the liquid level builds in the basement. The containment walls above grade and the containment dome used a specified external temperature of 95 F with a heat transfer coefficient of 2.0 Btu/hr-ft^2-F. For NPSH analysis, a multiplier of 1.2 was applied to the Direct heat transfer coefficient.

In the LOCA and MSLB peak temperature cases, a 1 ft^2 thermal conductor was added with the thickness of the containment liner and with a 1.2 multiplier on the Direct/DLM heat transfer coefficient to calculate a conservative containment liner temperature response. This is consistent with DOM-NAF-3, Section 3.3.3.

3.1.4 Plant Parameter Design Inputs

During the development of the NAPS GOTHIC containment models, all of the containment analysis design inputs were reviewed and some values were revised. Key input changes from the current UFSAR analyses are summarized below. Table 3.1-1 summarizes the range of key input parameters from the NAPS GOTHIC containment analyses.

- The minimum surface area for metal heat sinks in containment was changed based on a revised inventory that was documented in an internal calculation. The passive heat sink data used in the GOTHIC analyses is provided in Table 3.1-3. The metal and concrete heat sink minimum surface areas are 5% less than the nominal calculated values.

- Some of the assumed SI pump flow rates were revised based on hydraulic analyses of SI system performance. The range of assumed flow rates is listed in Table 3.1-1. The suction friction loss for one LHSI pump at maximum flow rate was revised from 9.2 ft to 8.8 ft using hydraulic analyses of the actual system configurations.

3.1.5 Containment Initial Conditions and Instrument Uncertainty

NAPS operates with a subatmospheric containment. As such, the selection of initial conditions for each accident analysis is consistent with Table 3.6-2 in DOM-NAF-3. The GOTHIC containment analyses include design inputs for plant parameters that are controlled by Technical Specifications, including containment air partial pressure, containment temperature, RWST temperature, and SW temperature. DOM-NAF-3, Section 3.6, describes how GOTHIC analyses could account for instrument uncertainty on the TS surveillance parameters in one of two ways. In the analyses in this report, instrument uncertainty was deterministically applied to the TS limit to develop a GOTHIC input (Option 1 in DOM-NAF-3). For example, the current TS limits on containment temperature are 86–120 F and the instrument uncertainty is 1.5 F. The GOTHIC analysis input range is 84.5–121.5 F. Table 3.1-1 defines the GOTHIC input assumptions for the TS parameters.

3.1.6 NPSH Available and Water Holdup

DOM-NAF-3, Section 3.8.1, describes the licensing basis for calculation of NPSHa for the NAPS LHSI and RS pumps. A specific value for containment overpressure credit in the determination of NPSH has not been previously provided to the NRC for review and approval. Rather, NRC approval has been directed at verification of the adequacy of the methodology used to determine that the available NPSH is greater than the required NPSH for these pumps. The GOTHIC analysis methodology for NPSH in Section 3.8 of DOM-NAF-3 ensures that an overall conservative calculation is performed to minimize containment pressure and maximize containment sump temperature. DOM-NAF-3, Section 4.4 demonstrated the application of the conservative GOTHIC calculation of LHSI pump NPSHa for Surry Power Station, and the containment response compared favorably to the LOCTIC analysis of record. The same methodology was applied for NAPS in benchmark analyses and produced a comparable response to LOCTIC.

The NPSHa result from GOTHIC is based on the conditions at the pump first-stage impeller elevation. The difference in elevation between the pump intake and the containment floor is included. Also, the pump suction friction and form losses (including the current clean sump screens) are specified in the junction between the containment and the pump. Therefore, the margin between the GOTHIC-calculated NPSHa and the required NPSH includes all essential elements of the problem except for strainer debris bed head loss, which is calculated external to GOTHIC and compared to the margin between NPSHa and required NPSH.

The NAPS NPSH calculations for the LHSI, IRS and ORS pumps employ the following conservative assumptions consistent with DOM-NAF-3, Section 3.8:

- A multiplier of 1.2 is applied to the Direct/DLM heat transfer coefficients for passive heat sinks.
- All of the spray water is injected as droplets into the containment atmosphere (nozzle spray flow fraction of 1) with the Sauter droplet size. Analyses are performed using the largest Sauter droplet size. A confirmatory analysis is performed by reducing the Sauter diameter by a factor of 2. The minimum NPSHa is reported from the case that provides the smaller NPSHa.
- The upper limit on containment free volume is used.
- The minimum containment air pressure is used.
- A minimum sump pool surface area is specified for the containment volume L/V interface area.
- For pump suction breaks, thermal equilibrium in the broken loop cold leg is forced using a liquid/vapor interface area of 1E+08 ft^2 consistent with DOM-NAF-3, Section 3.5.3.3.2. This

promotes thermal equilibrium between any vapor from the downcomer and the SI added to that cold leg, which produces elevated sump temperatures. The SI flow is split between the downcomer (for the intact cold legs) and the broken loop cold leg using a flow distribution that is conservative compared to a hydraulic analysis of the RCS during a LOCA.

- A conservative water holdup volume is subtracted from the GOTHIC-calculated containment liquid volume to reduce the sump water height. Control variables incorporate the timing of spray system actuation and filling the refueling canal and calculate the total decrement to the GOTHIC containment liquid volume fraction. The corrected liquid volume fraction is then entered into a table of containment water level versus volume to determine the sump level to be used in the NPSHa calculation. For the LHSI pumps, the holdup areas in containment are filled before the pumps draw from the containment sump. The RS pumps start earlier in the accident and the holdup volumes are not filled completely at pump start. In the NAPS NPSH analyses, the containment holdup volume includes the following items:

1) water added to the RS and QS system piping,
2) water trapped from transport to the containment sump in the refueling canal and reactor cavity,
3) condensed films on heat structures,
4) films that form on platforms and equipment when spray is initiated, and
5) water absorbed in insulation.

The water level in the NPSH analyses is based on a planned modification to install a drain path between the reactor cavity and the outer containment basement. The NPSH analyses assume this drain for the calculation of the water holdup volume in the reactor cavity and in the determination of containment water level versus liquid volume.

Table 3.1-1: Key Parameters in the Containment Analysis

Parameter	Value
Maximum Core Power (102% x 2893 rated thermal power), MWt	2951
TS Containment Air Partial Pressure, psia	TS Figure 3.6.4-1 (current) Figure 3.10-1 (proposed)
Containment Air Partial Pressure Uncertainty, psi	+/- 0.30
Containment Temperature, °F (includes 1.5 °F uncertainty)	84.5 – 121.5 (current) 84.5 – 116.5 (proposed)
Containment Relative Humidity, %	0-100
SW Temperature, °F (includes 3.0 °F uncertainty)	32 - 98
RWST Temperature, °F (includes 2.0 °F uncertainty)[1]	32 - 52
Accumulator Pressure, psia	590-705
Accumulator Temperature, °F	84.5 – 121.5
Accumulator Water Volume, ft^3 (includes uncertainty)	1007.3 – 1042.8
Accumulator Nitrogen Volume, ft^3	407.2 – 442.7
Minimum Service Water Flow Rate with 2% RSHX tube plugging, gpm	4410[2]
Maximum Service Water Flow Rate with 0% RSHX tube plugging, gpm	9,000
LHSI Injection Mode Flow Rate (Single-Train), gpm	3066 – 4201
Maximum LHSI Recirculation Mode Flow Rate (Single-Train), gpm	4050
HHSI Injection Mode Flow Rate (Single-Train), gpm	588 - 644
ORS Pump Flow Rate, gpm	3450 – 3750
IRS Pump Flow Rate, gpm	3100 – 3400
Minimum Casing Cooling Flow Rate to ORS Pump Suction, gpm	700
Casing Cooling Tank Available Volume, gallons	100,000
Casing Cooling Tank Maximum Temperature, °F (includes 3.0 °F uncertainty)	53
Maximum Casing Cooling Delivery Delay from CDA signal, sec	55
QS Flow Rate, gpm	Variable[3]
QS Bleed Flow Rate to IRS Pump Suction, gpm	150
QS Spray Delivery Delay from CDA signal, sec	56 - 70
LHSI Pump Suction Friction Loss at maximum 1-pump flow, ft	8.8

Parameter	Value
ORS Pump Suction Friction Loss at maximum flow, ft	5.1
IRS Pump Suction Friction Loss at maximum flow, ft	0.42
CDA High High Containment Pressure, psia	30
RWST WR Level for RS Pump Start (60% +/- 2.5% uncertainty)	57.5% - 62.5%
ORS Pump Start Time Delay after 60% RWST level + CDA, seconds (0 or 10 seconds for ramp to full flow depending on which is conservative)	0 - 10
ORS Piping Fill Time, seconds	46 - 61
IRS Pump Start Time Delay after 60% RWST level + CDA, seconds (+/- 12 second timer uncertainty + 0 or 10 seconds for ramp to full flow, depending on which is conservative)	108 - 142
IRS Piping Fill Time, seconds	52 – 55
RWST WR Level Setpoint for RMT (Plant Setpoint +/- 2.5% uncertainty)	16.9 – 21.4% (current) 13.5 – 18.5 % (proposed)
Time to complete RMT function, seconds	95 – 210
Minimum RWST volume at accident initiation, gallons	462,640
Current IRS Pump Start Delay, seconds [4]	395 – 405
Current ORS Pump Start Delay, seconds [4]	205 – 215
Minimum containment free volume, ft^3	1,825,000
Maximum containment free volume for NPSHa Analysis, ft^3	1,916,000

1) Minimum RWST temperature of 32 F is assumed for evaluation of the inadvertent QS actuation event, but the GOTHIC analyses use 38 F. Normal operating range for RWST temperature is 40-50 F.
2) The minimum SW flow rate per RSHX is 4500 gpm with no tube plugging. The flow rate is reduced to 4410 gpm to account for 2% tube plugging.
3) The QS flow rate varies with the differential pressure between the containment (C) and RWST water level (L).

C-L, psid	Minimum QS Pump Flow, gpm	Maximum QS Pump Flow, gpm
52.1	1265.5	1465.5
39.94	1473.7	1673.7
27.77	1657.35	1857.35
20.61	1755.4	1955.4
13.44	1847.4	2047.4
4.12	1959.4	2159.4
-5.21	2066.8	2266.8
-13.01	2153.7	2353.7
-22.71	2255.3	2455.3

4) The current timer setpoints are used for "current configuration" analyses.

Table 3.1-2: GOTHIC Model Heat Sink Material Properties

Material	Temperature deg-F	Density lbm/ft^3	Thermal Conductivity Btu/hr-ft-F	Specific Heat Btu/lbm-F
Carbon steel	70	490	27	0.10
Stainless steel	70	501	9.4	0.12
Concrete	75	142	1.0	0.156
Paint	75	110	0.125	0.10

Table 3.1-3: Containment Passive Heat Sinks

TC #	Description	Minimum Surface Area, ft^2	Thickness, inch
1	Interior Concrete Wall 1	7,741	6.006
2	Interior Concrete Wall 2	57,435	12.006
3	Interior Concrete Wall 3	51,064	18.006
4	Interior Concrete Wall 4	10,691	24.006
5	Interior Concrete Wall 5	8,674	27.006
6	Interior Concrete Wall 6	3,354	36.006
7	Cont Wall Below Grade	21,397	54.4026
8	Cont Wall Above Grade	28,090	54.4026
9	Containment Dome	24,925	30.5276
10	Containment Floor	11,757	146.699
11	Stainless Steel 0.3"-0.7"	9,378	0.360
12	Stainless Steel > 0.7"	330	1.490
13	Carbon Steel < 0.3"	74,920	0.225
14	Carbon Steel 0.3"-0.6"	12,304	0.333
15	Carbon Steel 0.6"-1.0"	1,413	0.921
16	Carbon Steel 1.0"-2.0"	17,749	1.430
17	Carbon Steel > 2.0"	1,969	2.239
18	Galvanized Metal	95,667	0.069
19	Containment Liner Temperature Response	1	54.4026
20	EQ Conductor	1	1.0
29	More Carbon Steel	21,054	1.143

3.2 Break Mass and Energy Release

3.2.1 LOCA Mass and Energy Releases

The break release methodology in DOM-NAF-3, Section 3.5 is applied. The GOTHIC model assumes a constant drop size of 100 microns for the liquid release from the break until after the blowdown phase, at which time a continuous liquid is assumed. LOCA mass and energy release data through the end of reflood is obtained from the current licensing basis analysis from the NAPS steam generator replacement project in 1992. The NAPS mass and energy release analyses used the NRC-approved codes and methods documented in WCAP-8264-P-A [9] and WCAP-10325-P-A [10].

During the post-reflood phase, the GOTHIC RCS system model is used to calculate the mass and energy release to the containment. The model was created using the guidelines in DOM-NAF-3, Section 3.5. The end-of-reflood mass and energy distribution in the primary system and steam generator secondary side is acquired from the Westinghouse mass and energy release analysis. The mass and energy release accounts for the transfer of decay heat and the stored energy in the primary and secondary systems to the containment.

Lumped volumes are used for the vessel, downcomer, intact loop cold legs, broken loop cold leg, steam generator (SG) secondary side, up flow steam generator tubes and down flow steam generator tubes. Separate sets of loop and secondary system volumes are used for the intact and broken loops with the connections between the broken loop and containment as necessary for the modeled break location. Separate thermal conductors model the core, primary metal, SG tubes, and SG secondary metal.

The decay heat is modeled by specifying a time dependent internal heat generation for the fuel. The 1979 ANS Decay Heat Standard is used consistent with DOM-NAF-3, Section 3.5.3.3.1.

The modeling approach outlined above successfully matched the long-term mass and energy release from the NRC-approved methodology employed in the current LOCTIC analysis of record [8]. The GOTHIC simplified RCS model ensures that the stored energy in the core, primary metal, and the SG secondary has been released to the containment when the vessel is fully depressurized and the acceptance criteria for containment depressurization and NPSHa are challenged. Additional description about this modeling was provided in Response #8 to the NRC Request for Additional Information on the Surry GOTHIC analysis submittal [8].

3.2.2 MSLB Mass and Energy Releases

The North Anna MSLB mass and energy data documented in WCAP-11431 [11] was generated using the NRC-approved methodology from WCAP-8822 [12] and the LOFTRAN computer code [13]. The analysis assumed two single failures: 1) the main steam non-return valve in the ruptured line fails to close, allowing all three SGs to blowdown until closure of main steam isolation valves; and 2) loss of one emergency bus. The NRC reviewed the MSLB mass and energy release data as part of a North Anna license amendment to increase the containment temperature limit. Section 5.3 in Attachment 3 of Reference 14 described the methodology and assumptions. The NRC Safety Evaluation Report was documented in Reference 15. The MSLB mass and energy release data from WCAP-11431 is applied in the GOTHIC analyses in Section 3.7.

3.3 LOCA Peak Pressure and Temperature

The peak containment pressure is a function of the initial total pressure and average temperature of the containment atmosphere, the containment free volume, the passive heat sinks in the containment, and the rates of mass and energy released to the containment. The passive heat sinks in the containment are assumed to be at the same initial temperature as the initial average containment atmosphere temperature. Maximizing the initial containment total pressure and average atmospheric temperature maximizes the calculated peak pressure. The LOCA peak containment temperature is obtained from the peak pressure case because the containment atmosphere is saturated.

The double-ended hot leg guillotine (DEHLG) break causes a more limiting blowdown peak pressure than the double-ended pump suction break (DEPSG). The LOCA peak pressure analyses assume maximum initial containment pressure, maximum air temperature, 100% relative humidity, minimum containment free volume, and minimum heat sink surface area. Table 3.3-1 documents the results for GOTHIC calculations that use the current and proposed TS containment air partial pressure limits and containment temperature limits (120 F vs. 115 F). The change to the RS pump start method and the SI RMT setpoint do not affect the LOCA peak pressure and temperature because the peak values occur before the spray systems actuate and before SI RMT. The magnitude of the containment peak pressure is governed by the heat transfer to the containment passive heat sinks. For the proposed TS limits, the peak pressure increases 0.6 psi to 57.4 psia. This is the result of increasing the initial air partial pressure by 0.6 psi, which increases the initial air mass, which expands when heated from the break energy. The air pressure increase is offset somewhat by the reduction in initial containment temperature and corresponding reduction in vapor pressure. The colder heat sink surfaces condense slightly more steam during the blowdown.

For both cases, the containment peak pressure is less than the design limit of 59.7 psia. In addition, the containment vapor temperature and liner temperature remain below 280 F. Figures 3.3-1 and 3.3-2 compare the GOTHIC containment pressure and vapor temperature response for both DEHLG cases. The effect of RS pump operation is evident in the current configuration analyses after the outside RS pump delay time of 210 seconds from CDA passes.

The MSLB analysis in Section 3.7 produces a more limiting peak containment pressure than the LOCA analysis by 0.3 psi. LOCA and MSLB events set the TS containment air partial pressure maximum allowable value of 12.3 psia in Section 3.10. The maximum initial air partial pressure is independent of SW temperature, because the peak pressure occurs well before SW affects heat removal; therefore, the maximum allowable pressure is a constant line in Figure 3.10-1. The TS upper limit above 55 F SW in Figure 3.10-1 is limited by the containment depressurization analyses (see Section 3.4). In summary, a maximum operating containment air partial pressure of 12.3 psia ensures that the LOCA peak pressure is less than the design limit of 59.7 psia.

Table 3.3-1: LOCA Peak Pressure and Temperature Analysis Results

	Current Configuration	Proposed Configuration
Initial Conditions		
TS Containment Air Partial Pressure, psia	11.7	12.3
Total Air Pressure (TS + 0.3 psi), psia	12.0	12.6
Initial Containment Temperature, F	121.5	116.5
Initial Containment Relative Humidity, %	100	100
Initial Vapor Pressure, psia	1.76	1.535
Initial Containment Pressure, psia	13.76	14.135
Results		
Peak Containment Pressure, psia	56.8	57.4
Time of Peak Containment Pressure, sec	19.12	19.07
Peak Containment Vapor Temperature, F	269.8	269.3
Peak Containment Liquid Temperature, F	251.0	250.5

Figure 3.3-1: Comparison of Containment Pressure from DEHLG Peak Pressure Analysis

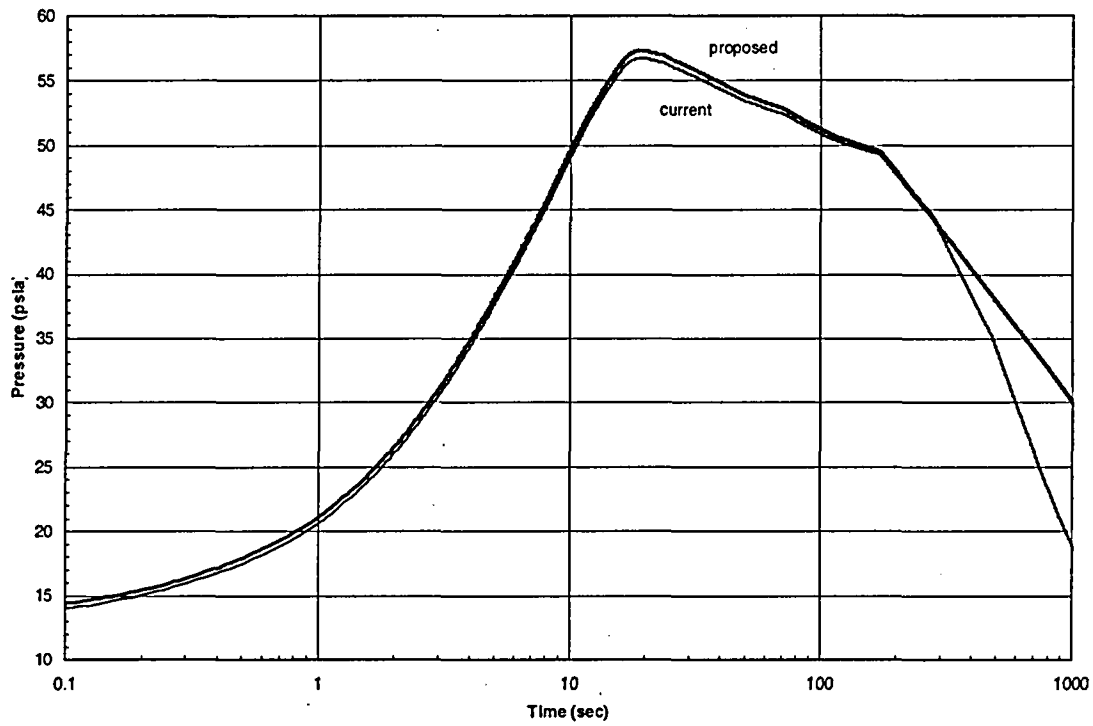
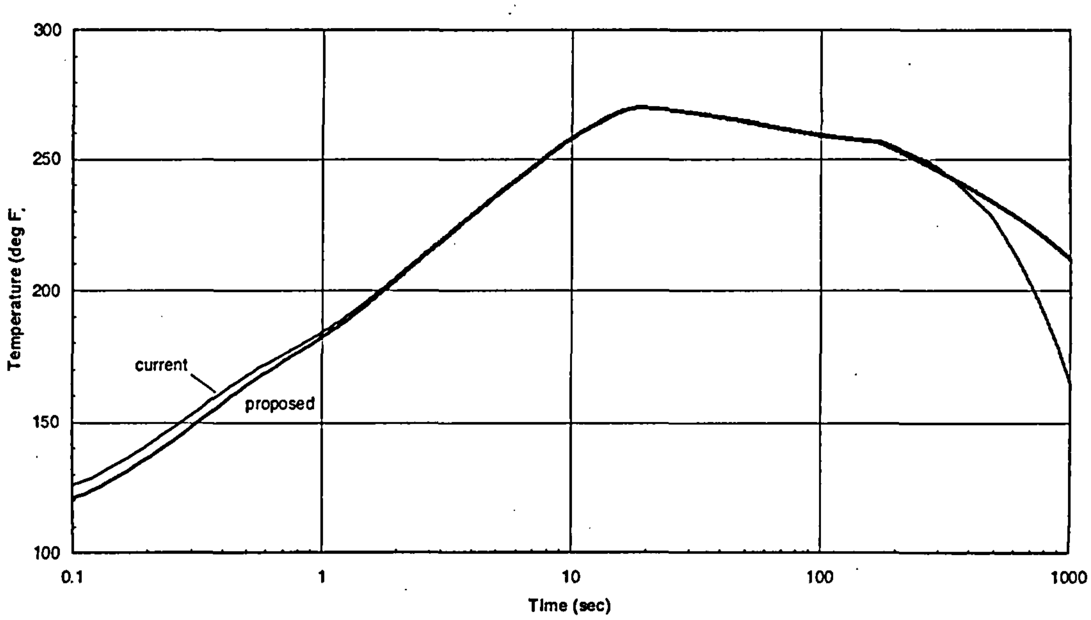


Figure 3.3-2: Containment Vapor Temperature from DEHLG Peak Pressure Analysis



3.4 LOCA Containment Depressurization

The depressurization analysis is performed to show that the containment can be returned to subatmospheric conditions consistent with the assumption for containment leakage in the dose consequences analysis. Currently, the UFSAR depressurization analyses using LOCTIC show that the containment is subatmospheric within one hour and remains subatmospheric thereafter. The current LOCA Alternate Source Term (AST) analysis assumes containment pressure is 0.5 psig from 1-4 hours and subatmospheric pressure after 4 hours [20], but the margin after the first hour has not been used to relax the containment analysis yet. To support the proposed configuration containment depressurization analyses, the AST licensing basis must be changed in accordance with Section 4.0 to accommodate a containment pressure less than 2.0 psig from 1-6 hours with subatmospheric pressure after 6 hours.

The time required to depressurize the containment and the capability to maintain it subatmospheric after a double-ended pump suction guillotine (DEPSG) break depends on the design of the containment depressurization systems, SW temperature, and the mass of air in the containment. The DEPSG break is limiting because it has the largest energy release to the containment due to the available energy removal from the SG secondary side. The loss of one emergency bus is the limiting single failure because it provides only one train of spray flow for containment atmosphere cooling. When SW temperature is elevated, it is more difficult to depressurize the containment and containment air partial pressure must be reduced to meet the depressurization limits.

Containment depressurization analyses were performed with GOTHIC for the current and proposed configurations to maximize the containment depressurization time (CDT) and the depressurization peak pressure (DPP). CDT represents the time when containment pressure first drops below atmospheric pressure. Once the operating QS pump is stopped after RWST depletion, only the RS system provides spray flow to the containment and at higher temperatures than the QS system (the maximum RWST temperature is 50 F). Once QS is terminated, the containment increases from subatmospheric conditions until it reaches the DPP, which is limited by the heat removal capacity of the RS system and the air mass in containment. A minimum initial containment temperature is conservative for DPP analyses, because higher initial air mass makes it more difficult to maintain subatmospheric conditions after QS termination. This response is evident in the current UFSAR anlasyes and in the GOTHIC analyses in this section.

<u>Current Configuration</u>

The limiting case for the current configuration occurs for TS limits of 11.7 psia air partial pressure, 38 F SW, and 86 F air temperature. The containment response is very similar to the Surry benchmark analysis to LOCTIC in Section 4.4 of DOM-NAF-3. In the short-term accident response, GOTHIC predicts a lower peak pressure and a higher sump temperature based on the Direct/DLM condensation and break effluent models. In the long-term, GOTHIC's lower containment pressure is attributed to the smaller superheated steam flow rate from the broken loop SG compared to the non-mechanistic Westinghouse FROTH analysis. The GOTHIC DEPSG model has removed the energy in the primary and secondary systems once the RCS is fully depressurized. The integral mass and energy releases were very close to the LOCTIC analysis of record. Containment pressure reaches subatmospheric conditions at 2604 seconds and the DPP is –1.06 psig at 6077 seconds (QS terminates at 5841 seconds). The current configuration analyses maintain a subatmospheric containment after one hour.

Proposed Configuration

The proposed changes to the RS pump start method were incorporated and the containment air pressure was increased until sufficient margin was retained to the containment pressure limits imposed by the new LOCA AST analysis (i.e., 2.0 psig from 1-6 hours). The analyses are performed for SW temperatures from 55-95 F using the corresponding TS containment air partial pressure limits in Figure 3.10-1. Below 55 F, the MSLB and LOCA peak pressure analyses set the TS containment air partial pressure upper limit. The reduction in allowable containment air partial pressure as SW temperature increases is required to meet the LOCA depressurization limits. The analyses in this section demonstrate that, for operation within Figure 3.10-1, the post-LOCA containment pressure is bounded by the pressure used to determine the containment leakage in the LOCA dose consequences analysis in Section 4.

Several sensitivity analyses were performed for the proposed configuration to identify the most limiting CDT and DPP results. Table 3.4-1 summarizes the results from two final analyses that use the matrix of limiting assumptions specified in Table 3.11-2. Case 1 is the limiting analysis at the proposed TS maximum air partial pressure of 12.3 psia and 55 F SW. Case 1 pressure is less than 2.0 psig within 1 hour, has a DPP of 0.78 psig in the 2nd hour after QS termination, and is subatmospheric within 4 hours. Case 2 was analyzed at the proposed TS maximum air partial pressure of 10.4 psia at 95 F SW. Case 2 pressure decreased to less than 2.0 psig faster than Case 1 with a smaller DPP, but it takes longer to reach subatmospheric conditions because of the 95 F SW temperature. Containment pressure is subatmospheric in less than 6 hours and remains subatmospheric thereafter.

Figures 3.4-1 (containment pressure), 3.4-2 (containment vapor and liquid temperature), and 3.4-3 (total RSHX heat rate) compare behavior from the current configuration case (TS limits of 11.7 psia, 86 F air, 38 F SW) and proposed configuration Case 1 (TS limits of 12.3 psia, 86 F air, 55 F SW). While the containment pressure and SW temperatures are different, the comparison illustrates the effect of delaying the RS pumps. As expected, the lack of RS spray and sump heat removal before 2180 seconds creates higher containment pressures and temperatures. However, the long-term pressures and temperatures are bounded by the assumptions in the LOCA AST analysis. The effect of the temperature and pressure profiles on equipment inside containment is addressed in Section 3.9.

Small Break LOCA Containment Depressurization

Changing the RS pump start from timers with fixed delays to an RWST level setpoint encouraged a review of the containment pressure and temperature response for small break LOCA (SBLOCA). The design basis large break LOCA causes a rapid pressurization of the containment and actuates a High High containment pressure signal within seconds. The RCS depressurizes quickly below the accumulator pressure and the LHSI pump shutoff head. The LHSI, HHSI, and QS pumps rapidly deplete the RWST inventory, such that the 60% RWST level setpoint is reached in a short period of time. The double-ended RCS pipe ruptures result in a large energy release to the containment and represent the most significant challenge to containment design criteria for peak pressure, peak temperature, and NPSHa for the LHSI and RS pumps. The large break LOCA analyses in this report have used the limiting single failures and ranged the possible pump flow rates to ensure that the most conservative response is obtained.

For SBLOCAs, the RCS pressure may stay above the LHSI pump shutoff head for a significant period of time. For this class of breaks, only the HHSI pumps are available to feed the RCS. If the break is large enough to actuate a CDA, then the QS pumps will start and deplete the RWST. However, until the RCS pressure is below the LHSI pump shutoff head, the RWST minimum depletion rate for one train of ESF (1 HHSI pump + 1 QS pump) is less than 3000 gpm and the time to reach the RS actuation setpoint of 60% RWST WR level is extended beyond the LBLOCA analyses in this section. Early in the event (~15 minutes), SBLOCA containment pressures and temperatures are lower than the LBLOCA response, but the SBLOCAs can extend the depressurization because of the slower drawdown of the RWST and release of RCS stored energy. As a result, the containment pressure and temperature profiles beyond 1 hour may be higher than those for RS pump start using the current timers, and the impact on EQ and the assumed containment leakage for dose consequences must be considered.

The NAPS SBLOCA Appendix K analysis for calculation of peak clad temperature (PCT) uses the Westinghouse NOTRUMP computer code to determine the RCS response. The most recent analysis included 2", 3", 4" and 6" effective diameter cold leg break sizes [NAPS UFSAR Section 15.3.1]. The 6" break produces a more rapid depressurization and accumulator actuation than the smaller breaks and PCT results are not reported in the UFSAR. Break mass and energy release data was obtained from the NOTRUMP analyses for 3" and 6" break sizes. Breaks larger than 6" depressurize the RCS quickly, require LHSI flow early in the accident, and reach the RS actuation setpoint in a time frame approaching that of the LBLOCA cases, which have a bounding containment response. Breaks 3" and smaller deplete the RWST slowly and would lead to procedure-driven operator action to depressurize the RCS using the secondary system.

The GOTHIC model for LOCA depressurization was used to predict the time to reach the RS pump start on 60% RWST level. Containment model assumptions were employed to maximize the time to start the RS pumps (e.g., maximum initial RWST volume, RWST level setpoint of 57.5% for RS pump start, and minimum QS and SI flow rates) and maximize containment pressure and vapor temperature (1 train of ESF with minimum flow rates). Cases were analyzed along the minimum and maximum operating limits in the proposed TS Figure 3.6.4-1. The upper limit statepoints are 55 F SW and 12.3 psia air pressure and 95 F SW and 10.4 psia air pressure. The lower limit statepoints are 10.3 psia air pressure over the SW temperature operating range.

The GOTHIC simplified RCS model was deactivated and NOTRUMP mass and enthalpy data was entered as a boundary condition to the containment. The data had to be extended to support the duration of the GOTHIC analyses. Starting at 2500 seconds for the 6" break, the break energy was based on the LBLOCA decay heat curve and conservative RCS stored energy. Energy removal through the SGs was ignored after 2500 seconds for conservatism. The energy release to the containment is conservative compared to expectations (the 3" break NOTRUMP analysis showed primary-to-secondary heat transfer start at ~1400 seconds). For the 3" break, the NOTRUMP mass and energy release data at 3000 seconds was extrapolated conservatively.

For the 6" break, the High High containment pressure was reached in less than 150 seconds and containment spray was delivered 70 seconds later. The RS pump start signal was reached at around 3700 seconds. Containment pressure at RS pump start was less than 29 psia and drops rapidly to subatmospheric conditions. For most cases, containment pressure was subatmospheric in less than 2 hours. For the most limiting case, containment pressure was subatmospheric in less than 4.5 hours.

For the 3" break, the High High containment pressure was reached at 410 seconds and containment spray was delivered 70 seconds later. The RS pump start signal was reached at around 5400 seconds. Containment pressure at RS pump start was less than 20 psia and drops rapidly once RS starts. The containment response for the 3" break was clearly bounded by the 6" break.

The purpose of the GOTHIC SBLOCA analyses was to show that the CDA actuation signal for QS initiation and the RS pump start signal would be reached to depressurize the containment to within acceptable limits for dose consequences and equipment qualification (EQ). The dose consequences from the SBLOCA are bounded by the LBLOCA. The SBLOCA containment pressure and temperature profiles were bounded by the EQ composite profiles. The GOTHIC analyses were conservative in assuming that long-term RCS energy was discharged only to the containment atmosphere. No credit was taken for energy removal from the SGs or for operator action to depressurize the RCS to use the LHSI pumps earlier and drain the RWST faster. For small LOCAs with a slow pressurization that takes a long time to reach the CDA setpoint, operators can initiate QS by procedure, which further ensures that containment pressure will be maintained within design limits for slow pressurization events.

Table 3.4-1: Containment Depressurization Results for Proposed Configuration

	Case 1	**Case 2**
Initial Conditions*		
TS Containment Air Partial Pressure, psia	12.3	10.4
Initial Containment Total Pressure, psia	13.2	11.3
TS Containment Air Temperature, F	86	86
TS SW Temperature, F	55	95
Event	**Time (seconds)**	
CDA High High containment pressure	2.6	3.2
SI flow initiated	27.0	27.0
Casing cooling flow delivered to containment	57.6	58.2
QS delivers spray to containment	72.6	73.2
End of reflood	253.4	253.4
ORS spray delivered to containment	2198.1	2177.0
IRS spray delivered to containment	2324.1	2303.0
Containment pressure < 2.0 psig	**3205.0**	**3112.0**
Switchover to SI recirculation mode complete	4442.4	4415.8
QS pump stopped	5857.2	5821.8
Depressurization peak pressure occurs	6680.0 **(0.78 psig)**	7823.0 **(0.40 psig)**
Casing cooling pump stopped	8626.9	8627.6
Containment pressure < 14.7 psia permanently	12,880	14,530

* Analyses include uncertainties of 0.30 psi air pressure, 1.5 F air temperature, and 3.0 F SW temperature. Vapor pressure is 0.60 psia at 84.5 F (100% humidity).

Figure 3.4-1: Comparison of Containment Pressure from DEPSG Depressurization Analysis

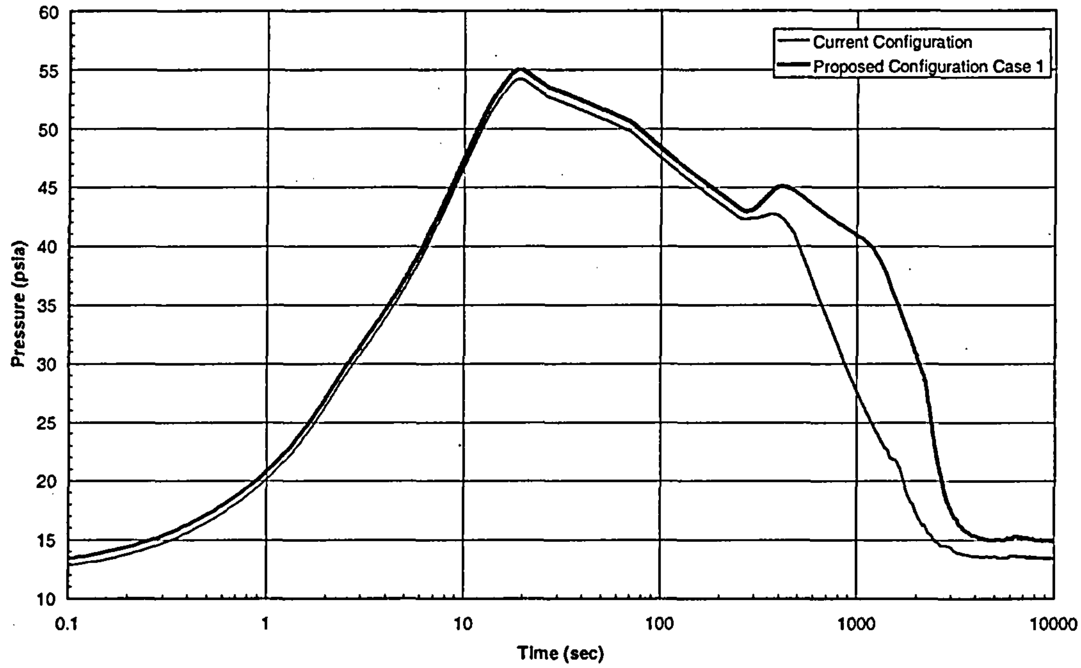


Figure 3.4-2: Comparison of Containment Temperature from DEPSG Depressurization Analysis

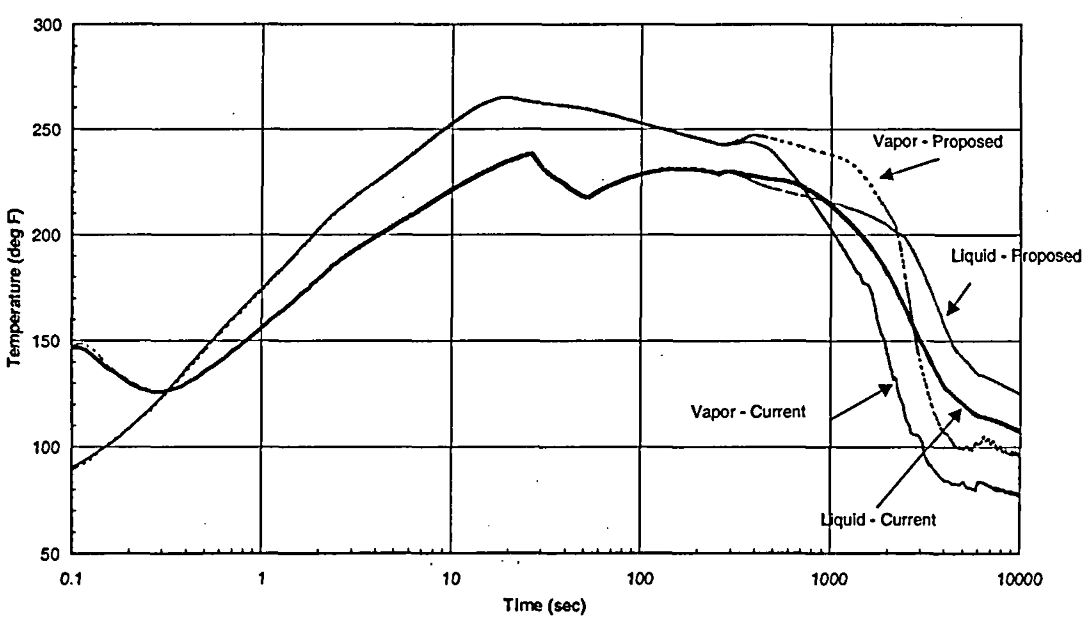
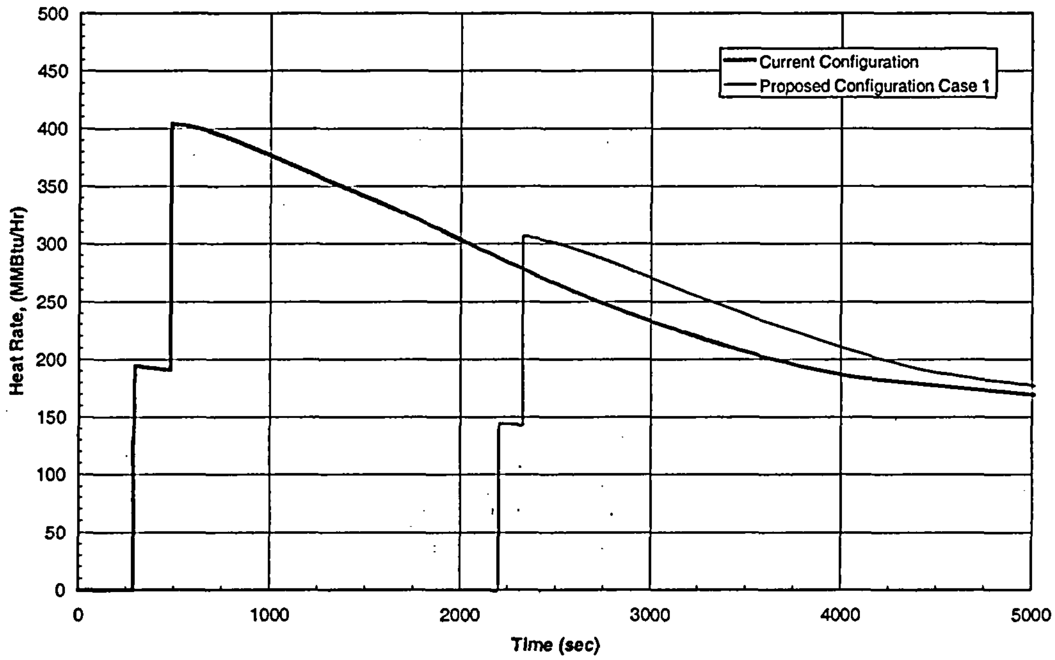


Figure 3.4-3: Comparison of Total RSHX Heat Rate from DEPSG Depressurization Analysis



3.5 LHSI Pump NPSH Analysis

A transient GOTHIC calculation is performed to demonstrate that the LHSI pumps have adequate NPSH throughout the postulated LOCA. The NPSH available (NPSHa) must be greater than the NPSH required at all times during the accident. The difference between available and required NPSH is margin. The calculation of NPSHa with GOTHIC follows the methodology outlined in Section 3.8 of DOM-NAF-3. The DEPSG break provides the limiting LHSI pump NPSH results because it causes the largest energy release to the containment before RMT. Assumptions for key input parameters were based on the matrix of conservative assumptions for the Surry LHSI pump NPSH analysis from DOM-NAF-3, Section 4.7, and were confirmed with sensitivity studies. For the proposed configuration, the effect of delaying the RS pumps encouraged several sensitivity studies to be repeated.

The LHSI recirculation flow rate is conservatively assumed to be 4050 gpm based on one emergency bus as the most limiting single failure. This single failure leaves one LHSI and one HHSI pump, maximizes the pump suction friction loss, maximizes the LHSI pump required NPSH, and minimizes NPSHa. The analyses assume minimum heat sink surface area, minimum RS flow rates, minimum SW flow rate, maximum QS flow rate, maximum SI flow rates, and maximum containment temperature. The TS range for SW temperature (35-95 F) was analyzed with 3 F uncertainty.

Current Configuration

Table 3.5-1 presents the LHSI pump NPSHa analysis results for the current configuration at 95 F and 73 F SW temperatures. The cases represent the current limiting cases with LOCTIC for LHSI pump NPSHa for the current TS Figure 3.6.4-1 that increases the containment air partial pressure limit from 8.85 psia at 73 F to 9.0 psia to 95 F. The LHSI pump minimum NPSHa of 14.49 ft occurs just after sump recirculation for a TS SW limit of 95 F. NPSHa increases to a value of 22.7 ft at 7200 seconds. High SW temperature is limiting because the RS pumps are removing sump energy for more than 2800 seconds before RMT is complete (see time sequence of events in Table 3.5-2). Higher SW temperature minimizes the containment energy removal during this long period of RS operation, although the effect of higher SW temperature is nearly offset by the lower air pressure at 73 F SW. Figures 3.5-1 (LHSI Pump NPSHa and water level), 3.5-2 (containment pressure and LHSI pump suction vapor pressure), 3.5-3 (containment vapor and liquid temperature), and 3.5-4 (RSHX heat rate) show the performance for the LHSI pump NPSHa analysis at 95 F SW.

Proposed Configuration

For the proposed configuration with delaying the RS pumps, the sensitivity studies on limiting single failure and plant parameters were confirmed. The results are summarized in Table 3.11-2. Table 3.5-3 summarizes the LHSI pump NPSHa analysis results for the proposed configuration performed at 10 F SW temperature steps with a TS containment air partial pressure of 10.3 psia. These analyses include the change to the SI RMT setpoint from 19.4% to 16.0% RWST WR level and the lower containment air temperature limit of 115 F. Table 3.5-4 provides the time sequence of events for select cases.

The delayed RS pump start reduces the system operating time before RMT from 2800 seconds to less than 1700 seconds, and NPSHa decreases. The increase in containment air pressure and lower system energy from the reduced heat sink initial temperature provide NPSH margin. During this shorter window, lower SW temperature brings down the containment pressure quickly but the sump temperature holds up. In the current configuration, the maximum SW temperature was limiting, because the RS pumps start within 400 seconds of the CDA signal and had 2800 seconds of operation before RMT. Colder SW temperature would remove more energy from the containment through the RSHXs. In the proposed configuration, lower SW temperature has become limiting because the shorter operation period of RS before RMT provides less cooling of the sump liquid while still generating low containment pressures. There is a tradeoff between reduced spray temperature and reduced sump temperature. Once SW temperature drops below 75 F, the minimum NPSHa has little variability around 15.0 ft. As SW temperature decreases, both the containment pressure and sump temperature decrease and the effect of each change on NPSHa is offset.

Since the minimum NPSHa is observed to be stable over 10 F steps in SW temperatures, the selection of a limiting case is only necessary for graphing plots for the UFSAR. While several cases along the air partial pressure limit generate about the same minimum NPSHa, the analysis at 10.3 psia and 75 F SW temperature (Case 5) is selected as the limiting case for showing transient behavior. Figures 3.5-5 (LHSI pump NPSHa and water level), 3.5-6 (containment and LHSI pump suction vapor pressure), 3.5-7 (containment vapor and liquid temperature), and 3.5-8 (RSHX heat rate) illustrate the performance of key variables for the LHSI pump NPSHa analysis at 75 F SW.

Note that Section 3.6 shows that the RS pumps have more NPSH margin than the LHSI pump for a containment air partial pressure of 10.3 psia. Therefore, the LHSI pump NPSH cases set the TS limit for minimum containment air partial pressure.

Table 3.5-1: LHSI Pump NPSHa Analysis Results - Current Configuration

Initial Conditions	Case 1	Case 2
TS Initial Containment Air Partial Pressure, psia	9.0	8.85
Initial Containment Total Pressure, psia	10.46	10.31
Initial Air Temperature, F	121.5	121.5
Relative Humidity, %	100	100
TS SW Temperature, F	95	73
Results at Time of Minimum NPSHa		
Minimum NPSHa, ft	14.49	14.65
Margin to NPSH required of 13.82 ft	1.09	1.25
Time of minimum NPSHa, sec	3180	3168
Containment pressure, psia	10.53	9.69
Containment vapor pressure, psia	1.32	0.90
Containment liquid temperature, F	168.0	160.3
Containment vapor temperature, F	111.4	96.9
Water level, ft (referenced to 216.54 ft)	5.24	5.23
LHSI pump suction pressure, psia	11.48	10.63
LHSI pump suction vapor pressure, psia	5.73	4.80
Integral energy release, MBtu	745.8	745.8
Integral mass release, Mlbm	2.544	2.540

Table 3.5-2: Time Sequence of Events for LHSI Pump NPSHa Analysis (Current Configuration)

Time in seconds	Case 1	Case 2
Accident Start	0	0
CDA Signal on High-High Pressure	4.1	4.2
Start SI	20.8	20.8
Casing cooling flow reaches containment	59.1	59.2
QS flow reaches containment	74.1	74.2
End of reflood phase	253.37	253.37
ORS flow reaches containment	263.7	263.7
IRS flow reaches containment	450.8	450.9
SI RMT initiated at 21.9% WR level	3077.5	3066.1
SI RMT complete (95 second delay)	3172.5	3161.1
QS termination	5803.5	N/A
Transient Termination	7200	3600

Table 3.5-3: LHSI Pump NPSHa Analysis Results - Proposed Configuration

Initial Conditions	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
TS Containment Air Pressure, psia*	10.30	10.30	10.30	10.30	10.30	10.30	10.30
TS SW Temperature, F	35	45	55	65	75	85	95
Containment Temperature, F	116.5	116.5	116.5	116.5	116.5	116.5	116.5
Results at Time of Minimum NPSHa							
Minimum LHSI Pump NPSHa, ft	15.13	15.03	15.11	15.01	**14.97**	15.19	15.48
Margin to NPSH required of 13.4 ft, ft	1.73	1.63	1.71	1.61	**1.57**	1.79	2.08
Time of minimum NPSHa, sec	3381	3383	3384	3385	3388	3390	3393
Containment total pressure, psia	10.53	10.72	10.98	11.21	11.43	11.79	12.28
Containment liquid temperature, F	166.7	168.5	170.2	172.1	173.7	175.6	177.7
Containment vapor temperature, F	79.1	84.5	91.1	96.4	101.2	108.4	116.8
Water level, ft (referenced to 216.54 ft)	5.46	5.46	5.46	5.47	5.47	5.47	5.47
LHSI suction pressure, psia	11.56	11.75	12.01	12.24	12.46	12.82	13.31
LHSI suction vapor pressure, psia	5.55	5.79	6.02	6.29	6.53	6.81	7.18
Integral energy release, MBtu (CV 201)	761.0	760.4	759.6	759.3	757.3	756.7	754.7

* GOTHIC total containment pressure is 11.535 psia from TS air pressure – 0.3 psi uncertainty + 1.535 psia vapor pressure for 100% humidity at 116.5 F.

Table 3.5-4: Time Sequence of Events for LHSI Pump NPSHa Analyses - Proposed Configuration

Time in seconds	Case 1	Case 3	Case 5	Case 7
Accident Start	0.0	0.0	0.0	0.0
CDA Signal on High-High Pressure	3.6	3.6	3.6	3.6
Start SI	20.8	20.8	20.8	20.8
Casing cooling flow reaches containment	58.6	58.6	58.6	58.6
QS flow reaches containment	73.6	73.6	73.6	73.6
End of reflood phase	253.4	253.4	253.4	253.4
57.5% RWST level reached	1642.2	1642.2	1642.2	1642.2
ORS flow reaches containment (+71 seconds)	1713.2	1713.2	1713.2	1713.2
IRS flow reaches containment (+197 seconds)	1839.2	1839.2	1839.2	1839.2
Early SI RMT initiated at 18.5% RWST level (16% setpoint + 2.5% uncertainty)	3278.1	3281.8	3284.8	3289.9
SI RMT complete (95 second delay)	3373.1	3376.8	3379.9	3384.9
QS termination	5570.9	5580.4	5590.9	5607.8
Transient Termination	7200	7200	7200	7200

Figure 3.5-1: LHSI Pump NPSHa - Current Configuration (9.0 psia, 95 F)

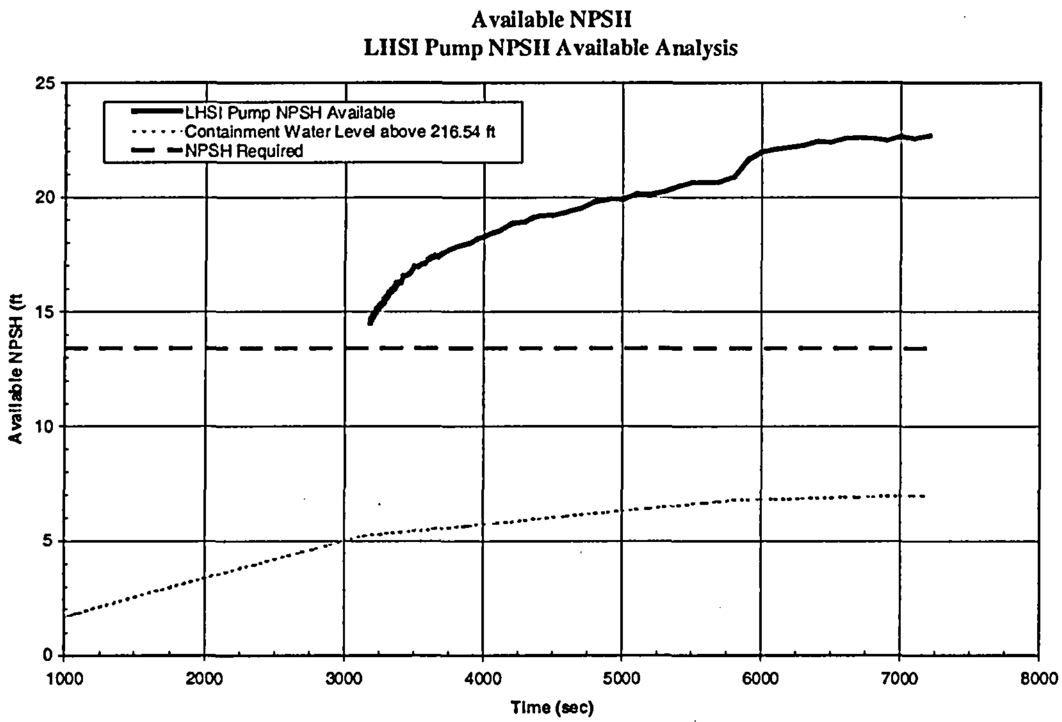


Figure 3.5-2: Containment Pressure from LHSI Pump NPSHa Analysis - Current Configuration

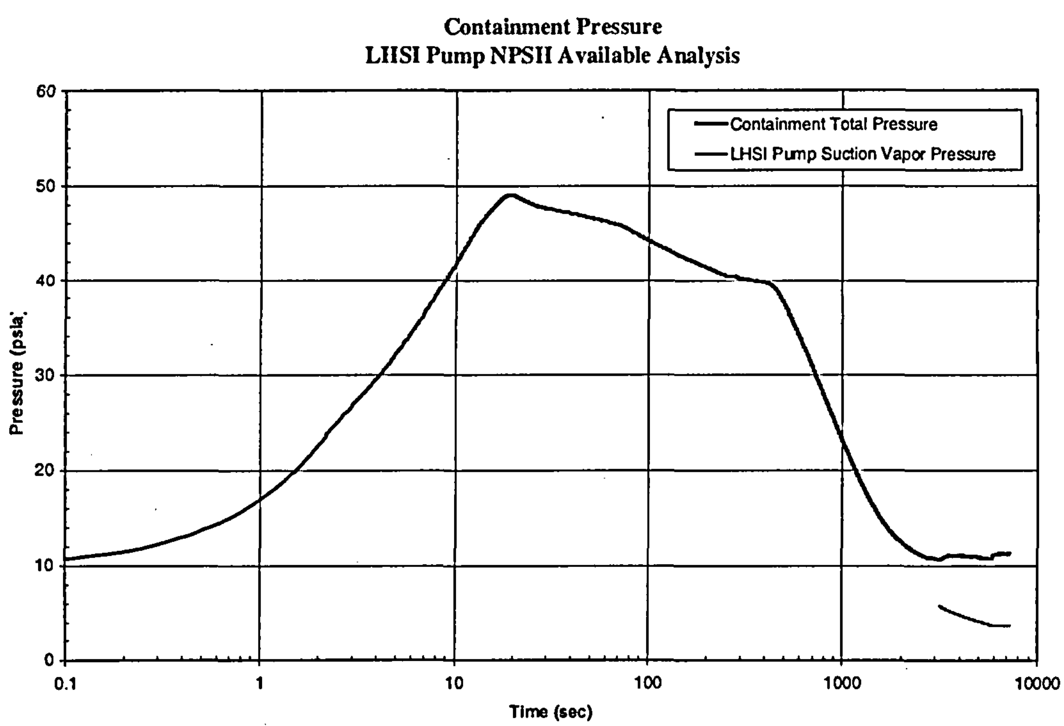


Figure 3.5-3: Containment Temperature from LHSI Pump NPSHa Analysis – Current Configuration

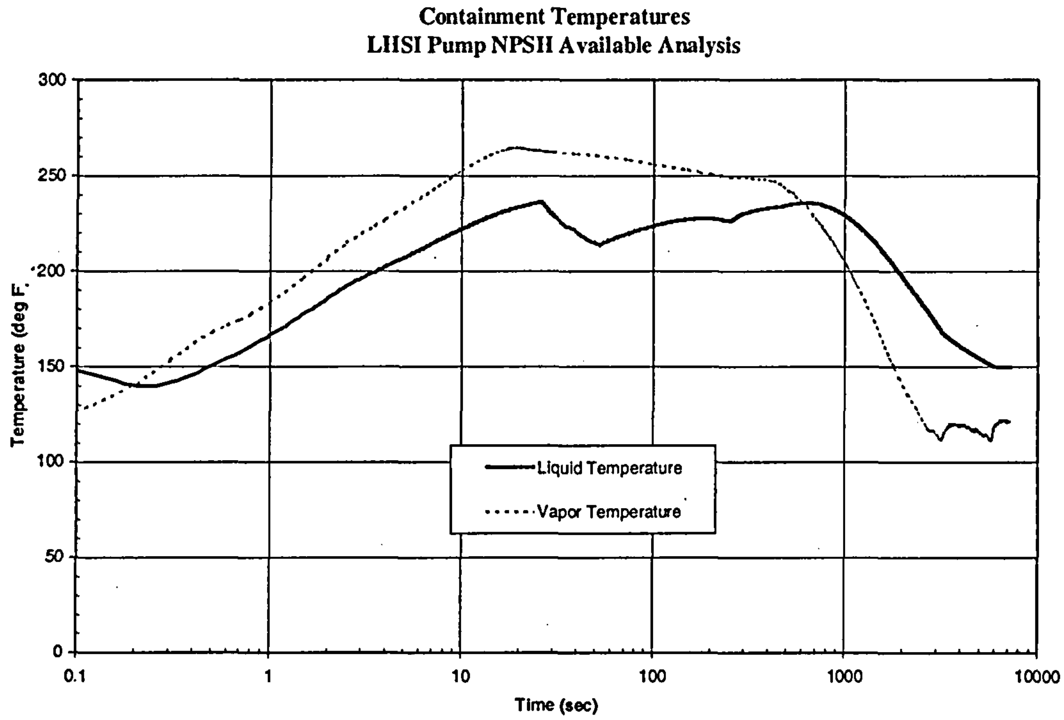


Figure 3.5-4: Total RSHX Heat Rate from LHSI Pump NPSHa Analysis – Current Configuration

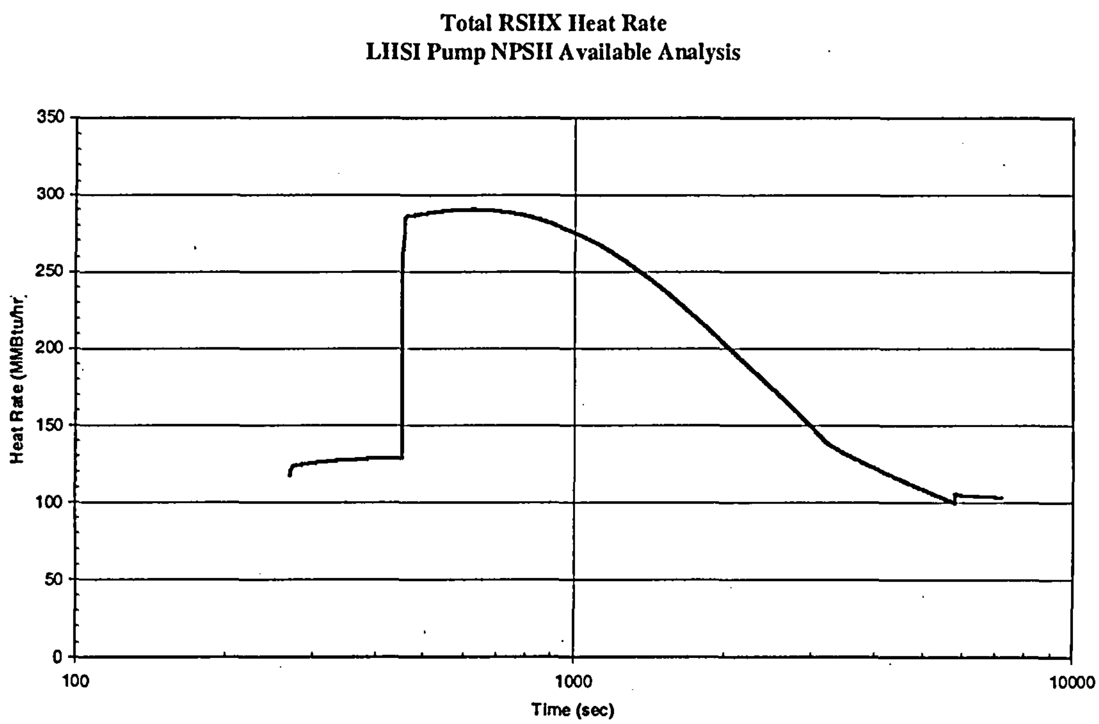


Figure 3.5-5: LHSI Pump NPSHa - Proposed Configuration (10.3 psia, 75 F)

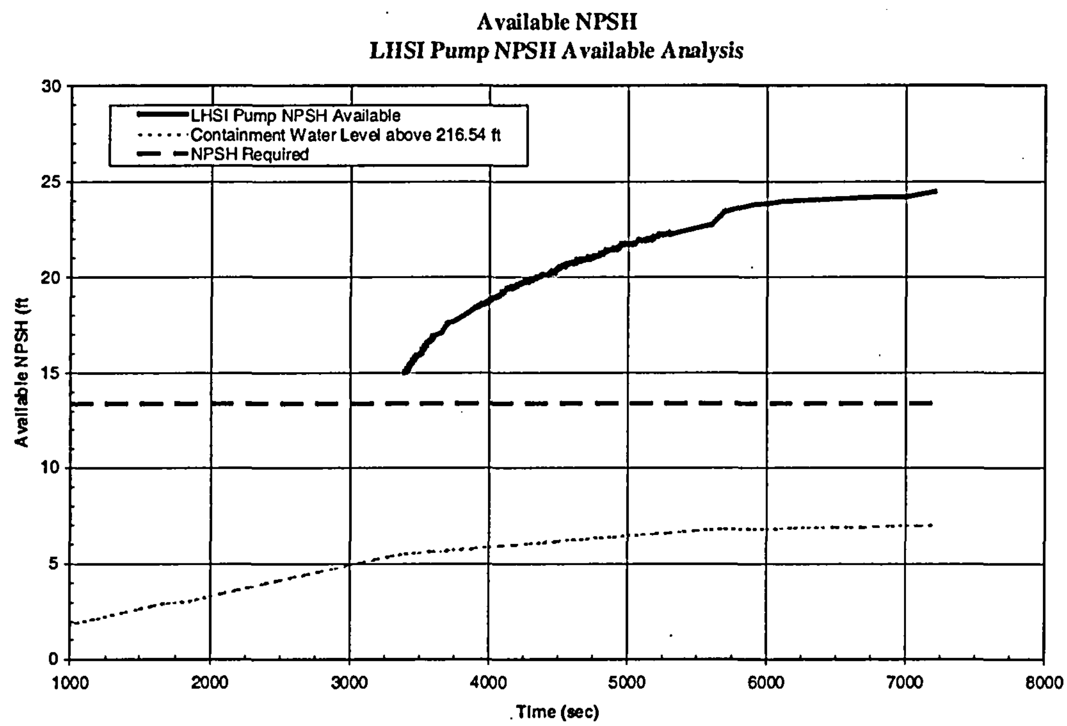


Figure 3.5-6: Containment Pressure from LHSI Pump NPSHa Analysis – Proposed Configuration

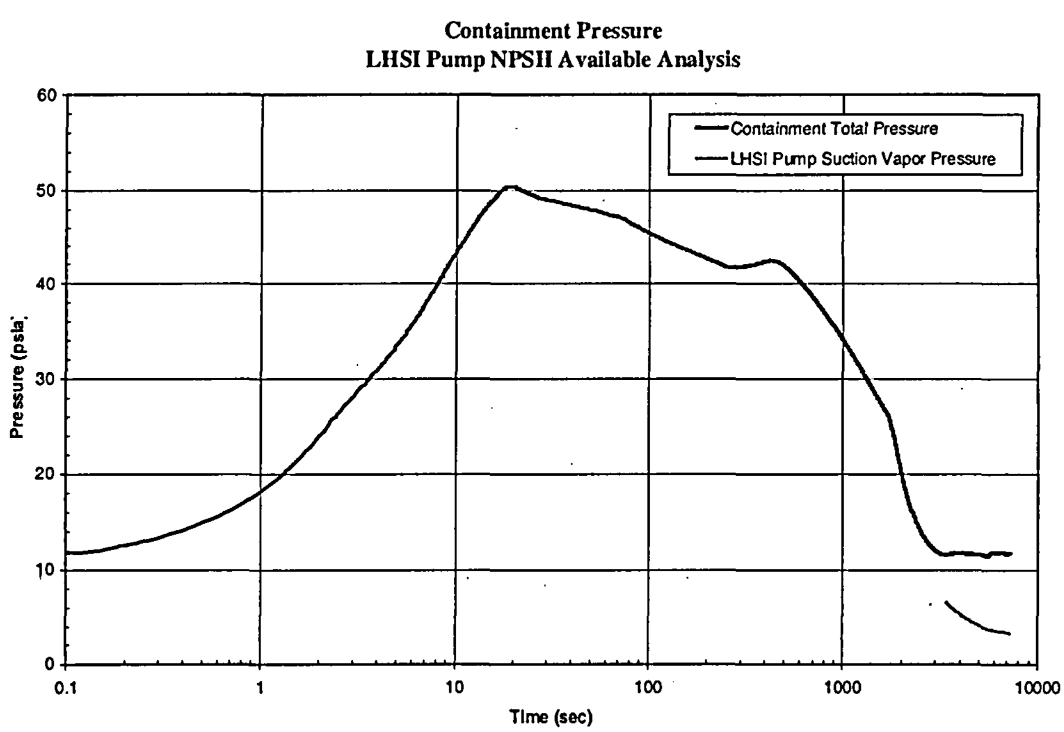


Figure 3.5-7: Containment Temperature from LHSI Pump NPSHa Analysis – Proposed Configuration

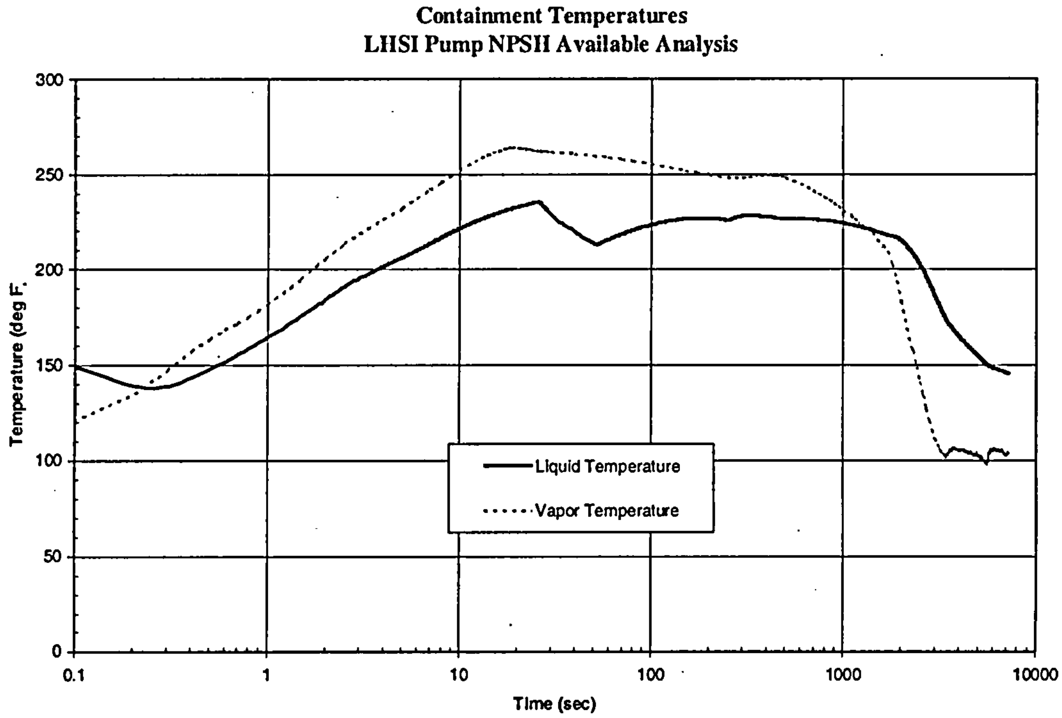
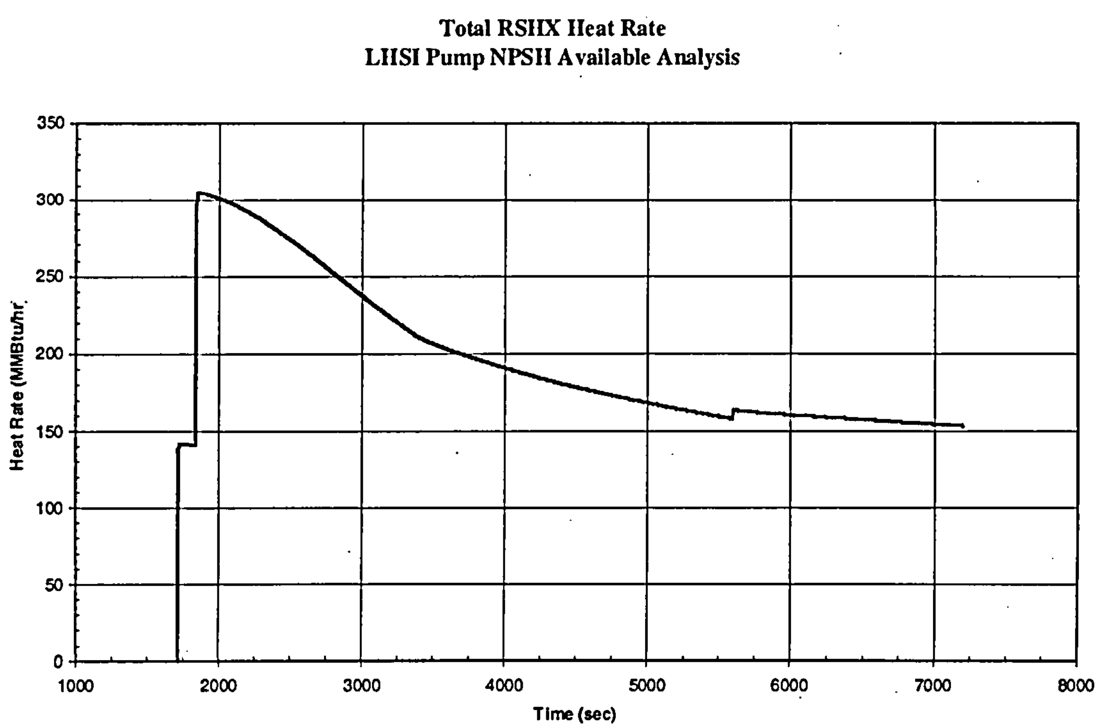


Figure 3.5-8: Total RSHX Heat Rate from LHSI Pump NPSHa Analysis - Proposed Configuration



3.6 RS Pump NPSH Analysis

A transient GOTHIC calculation is performed to demonstrate that the IRS and ORS pumps have adequate NPSH throughout the postulated LOCA. The NPSHa must be greater than the NPSH required at all times during the accident. The difference between available and required NPSH is margin. The calculation of NPSHa with GOTHIC follows the methodology outlined in Section 3.8 of DOM-NAF-3. Section 3.7 demonstrates that the RS pumps are not needed for MSLB mitigation, so only LOCA events are analyzed for RS pump NPSHa.

Maximum RS pump flow rate is conservative for determining the NPSHa for that pump because it causes the highest suction friction loss and imposes that most restrictive NPSH required. LOCTIC analyses have shown the IRS pump NPSH margin to be slightly more limiting than the ORS pump when considering the key factors that affect the pump suction conditions: 1) the ORS pump receives a minimum of 700 gpm casing cooling water (53 F) while the IRS pump receives 150 gpm of RWST water (52 F); 2) the IRS pump suction friction loss is 4.68 ft smaller (0.42 ft versus 5.1 ft for the ORS pump); 3) the ORS pump NPSH required is 1.7 ft higher (11.3 ft versus 9.6 ft) at the maximum pump flow rates; and 4) the IRS pump has 0.14 ft of extra head because the elevation of the pump impeller centerline is at –6.71 ft while the ORS pump impeller centerline is at –6.57 ft. With GOTHIC, the IRS and ORS pump NPSHa are tracked for all sensitivity runs to identify the specific break, single failure, and design inputs that minimize NPSHa for each RS pump.

Current Configuration

For the current configuration, sensitivity studies were performed on break location, single failures, and key input parameters to develop a matrix of conservative assumptions as specified in DOM-NAF-3, Section 4.7. Tables 3.6-1 and 3.6-2 present the RS pump NPSHa analysis results for the current configuration for points along the current TS Figure 3.6.4-1. The DEHLG break is limiting because the mass and energy data maximize the energy in the containment sump early in the accident when the RS pumps are running. The limiting single failure is the loss of 1 LHSI pump (consistent with LOCTIC), which produced a slightly lower NPSHa than the assumption of no failure (full ESF). The TS statepoint of 8.85 psia and 73 F SW (Case 3) produces the limiting IRS pump NPSHa of 12.17 ft, with adequate margin to the NPSH required of 9.6 ft. Figures 3.6-1 (available NPSH and water level), 3.6-2 (containment and IRS pump suction vapor pressure), 3.6-3 (containment vapor and liquid temperature) and 3.6-4 (RSHX heat rate) illustrate the performance of key variables from Case 3.

The minimum ORS pump NPSHa occurs for the same assumptions except for use of a minimum RWST temperature of 38 F (TS minimum 40 F - 2 F uncertainty) and minimum IRS pump flow. Case 5 in Table 3.6-1 documents the results at the time of minimum ORS pump NPSHa and Figure 3.6-5 shows the transient NPSHa for the ORS pump. The minimum NPSHa of 15.30 ft has 4.0 ft of margin. The IRS pump is more limiting for the current configuration.

Proposed Configuration

For the proposed configuration that delays the RS pumps, sensitivity studies on break location, single failure and plant parameters were repeated. The results are summarized in Table 3.11-2. Changing the RS pump start method causes a significant increase in NPSHa for the IRS and ORS pumps. While the containment pressure is much lower at the time of minimum NPSHa, the sump temperature is also much lower than the current configuration cases because the cold casing cooling water and QS bleed water is being injected directly to the sump before the RS pumps start. This extended cold water injection drops the average sump fluid temperature by a large amount in all cases. In addition, the delayed RS pump start allows for a higher water level to contribute to the NPSH margin gain. Based on these benefits, it is expected that the limiting failure would provide the smallest amount of sump subcooling and water level benefit before RS system activation. It is seen later that the failure of a casing cooling pump and the loss of an emergency bus provide the smallest benefits to NPSHa. Eliminating casing cooling flow of 700 gpm at 53 F to the sump produces the lowest containment water level and hottest sump water.

Tables 3.6-3 and 3.6-4 compare the results of DEPSG and DEHLG analyses using the proposed plant configuration for several single failures. The analyses were performed at the proposed TS minimum air partial pressure of 10.3 psia and 35 F SW. The cold SW temperature produces cold RS spray that provides a fast containment depressurization. The DEPSG break produces a higher long-term energy release to the containment because of the available energy in the SG secondary side. Delaying the start of the RS pumps moves the pump operation into a time period when the DEPSG break energy produces a more limiting set of sump conditions. At the time of minimum NPSHa, the DEPSG case has a higher containment pressure, sump temperature, and water level. The minimum NPSHa occurs later than the DEHLG case because it takes longer for the spray systems to depressurize the larger energy release and reduce the containment pressure. For all single failure scenarios with the delayed RS pump start, the DEPSG break produces a lower NPSHa than the DEHLG break.

The minimum NPSHa for the IRS pump is 15.12 ft (5.52 ft of margin) for the loss of an emergency bus (Case 2 in Table 3.6-3). The loss of QS bleed flow and the casing cooling pump on the failed bus provide the minimum subcooling and water level benefit. This more than offsets the lower spray flow rate compared to other cases. Figures 3.6-6 (available NPSH and water level), 3.6-7 (containment and IRS pump suction vapor pressure), 3.6-8 (containment vapor and liquid temperature), and 3.6-9 (RSHX heat rate) illustrate the performance of key variables for Case 2.

The minimum NPSHa for the ORS pump is 18.73 ft, with 7.43 ft of margin, for the loss of a casing cooling pump (Case 6 in Table 3.6-3). The IRS pump continues to have more NPSH margin than the ORS pump. Figures 3.6-10 through 3.6-13 show the behavior of key variables from the ORS pump NPSH limiting case.

For the LOCA analyses in this section, the minimum containment water level is 1.86 ft above 216'11" floor elevation (where the sump is located) when the ORS pump starts for Case 6 (loss of a casing cooling pump). This water level assumes a conservative holdup volume in containment of about 42,400 gallons and earliest pump start using 2.5% level uncertainty on the trip setpoint.

Long-term NPSH Margin for RS Pumps

When the RWST and casing cooling tanks are emptied, the injection flow to the RS pump suctions is lost. However, significant NPSH margin is available at these times and there is no adverse effect on long-term containment cooling. Case 6 was analyzed for 10,000 seconds to show the effects of exhausting the tanks. When QS stops on empty RWST at 2959 seconds, the IRS pump NPSHa changes from 32.1 ft to 31.7 ft but then continues to increase as sump temperature drops. When casing cooling stops at 8628 seconds, the ORS pump NPSHa changes from 31.6 ft to 28.8 ft and remains level for the duration of the analysis. The final containment water level is 7.0 ft above 216.54'. There is sufficient NPSH margin for long-term cooling from the RS system.

Table 3.6-1: Results for RS Pump NPSHa Analyses (Current Configuration)

GOTHIC Case →	IRS Case 1	IRS Case 2	IRS Case 3	IRS Case 4	ORS Case 5
TS Containment Air Partial Pressure, psia	10.25	9.60	8.85	9.00	8.85
Initial Containment Pressure, psia*	11.71	11.06	10.31	10.46	10.31
Initial Air Temperature, F	121.5	121.5	121.5	121.5	121.5
TS SW temperature, F	35	55	73	95	73
Results					
Minimum NPSHa, ft	12.41	12.32	**12.17**	12.85	**15.30**
NPSH Required	9.6	9.6	**9.6**	9.6	**11.3**
Margin to NPSH Required, ft	2.81	2.72	**2.57**	3.25	**4.00**
Time of minimum NPSHa, sec	633.2	655.3	686.2	683.4	756.3
Containment pressure, psia	13.02	12.75	12.13	13.62	10.18
Containment liquid temperature, F	205.7	204.8	202.3	207.8	190.4
Containment vapor temperature, F	132.8	137.6	139.4	152.6	111.2
Water level, ft (referenced to 216.54 ft)	1.28	1.32	1.39	1.38	1.55
Pump suction pressure, psia	16.36	16.11	15.52	17.00	11.6
Pump suction liquid temperature, F	198.9	198.0	195.7	200.9	164.4

* GOTHIC total pressure is TS air pressure – 0.3 psi uncertainty + 1.76 psia vapor pressure.

Table 3.6-2: Time Sequence of Events for RS Pump NPSHa (Current Configuration)

Time in seconds	IRS Case 3	ORS Case 5
Accident Start	0.0	0.0
CDA High High Pressure	4.19	4.19
Start SI	24.0	24.0
Casing cooling flow reaches containment	59.2	59.2
QS flow reaches containment	74.2	74.2
End of reflood phase	170.8	170.8
ORS flow delivered to containment	255.9	255.9
IRS flow delivered to containment	451.3	451.3
RS pump minimum NPSHa	686.2 (IRS)	756.3 (ORS)
Transient Termination	1800	1800

Table 3.6-3: RS Pump NPSHa Results by Break and Single Failure for Proposed Configuration (10.3 psia, 35 F SW)**

GOTHIC Case →	1	2	3	4	5	6	7	8	9	10	11	12
Break Location	DEHLG	DEPSG	DEHLG	DEPSG	DEHLG	DEPSG	DEHLG	DEPSG	DEHLG	DEPSG	DEPSG	DEPSG
Single Failure	Emergency bus		QS Pump		Casing Cooling Pump		None		LHSI Pump		ORS pump	IRS pump
Results												
IRS Pump Minimum NPSHa, ft	19.77	**15.12**	20.94	17.71	17.62	15.78	18.85	17.57	18.50	16.81	18.28	17.76
Time of IRS minimum NPSHa, sec	1895	2083	1623	1744	1306	1465	1263	1394	1313	1443	1478	1456
Containment pressure, psia	11.1	13.0	10.6	11.6	11.2	12.0	10.9	11.7	10.9	11.9	11.6	11.5
Containment liquid temperature, F	182.6	204.7	175.0	191.3	188.4	197.8	183.0	192.1	184.3	195.4	190.3	191.0
Pump suction liquid temp, F	176.8	197.8	169.6	185.1	182.4	191.3	177.2	185.9	178.5	189.0	184.1	184.8
Water level, ft (referenced to 216.54 ft)	3.07	3.44	2.93	2.87	2.72	3.15	2.80	3.18	2.81	3.18	3.48	3.43
Integral energy release, MBtu	483.6	628.0	469.2	593.0	443.8	558.0	440.1	549.7	440.4	552.3	558.6	557.1
ORS Pump Minimum NPSHa, ft	20.34	19.31	20.56	19.59	18.97	**18.73**	19.47	19.45	19.28	19.17	20.06	19.70
Time of ORS minimum NPSHa, sec	1964	2250	1657	1811	1354	1518 #	1297	1454	1351	1519	1521	1506

* The DEHLG break analyses for IRS and ORS pump failures were analyzed. Detailed results were omitted from the table because they were bounded by the DEPSG.

** All cases analyzed at 116.5 F containment temperature.

At the time of minimum ORS pump NPSHa, the containment pressure is 11.2 psia, the ORS pump suction pressure is 13.24 psia, the containment liquid temperature is 193.5 F, the ORS pump suction liquid temperature is 166.8 F, and the water level is 3.26 ft above 216.54 ft.

Table 3.6-4: Time Sequence of Events from Limiting RS Pump NPSHa Analyses (Proposed Configuration)

Time reported in seconds	Case 2 for IRS Pump DEPSG, emergency bus failure	Case 6 for ORS Pump DEPSG, casing cooling pump failure
Accident Start	0.0	0.0
CDA High High Pressure	3.63	3.63
Start SI	20.8	20.8
Casing cooilng flow reaches containment	58.6	58.6
QS flow reaches containment	73.6	73.6
End of reflood phase	253.4	253.4
RS pump start signal reached (62.5% WR RWST level)	1439.9	1020.0
ORS flow delivered to containment	1485.9	1066.0
IRS flow delivered to containment	1599.9	1180.0
RS pump minimum NPSHa	2083 (IRS)	1518 (ORS)
SI RMT starts	3151.8	2345.7
QS flow stopped on empty RWST	> 3600	2958.5
Casing cooling tank emptied	> 3600	8628.0
Transient Termination	3600	10,000

Figure 3.6-1: IRS Pump NPSHa - Current Configuration (8.85 psia, 73 F)

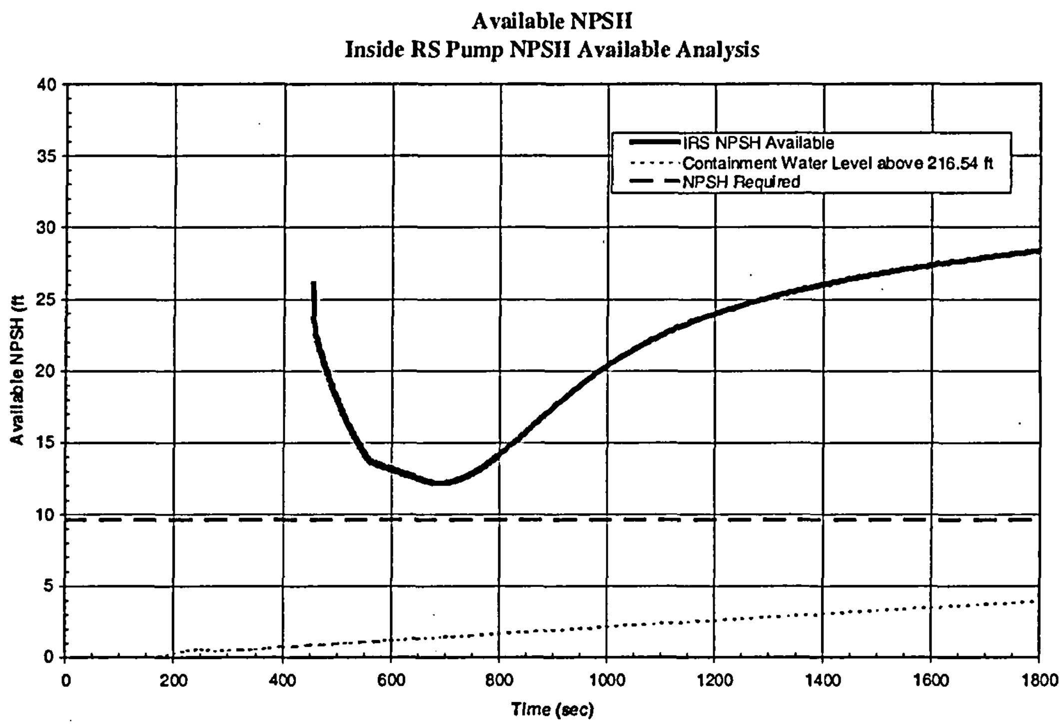


Figure 3.6-2: Containment Pressure from IRS Pump NPSHa Analysis – Current Configuration

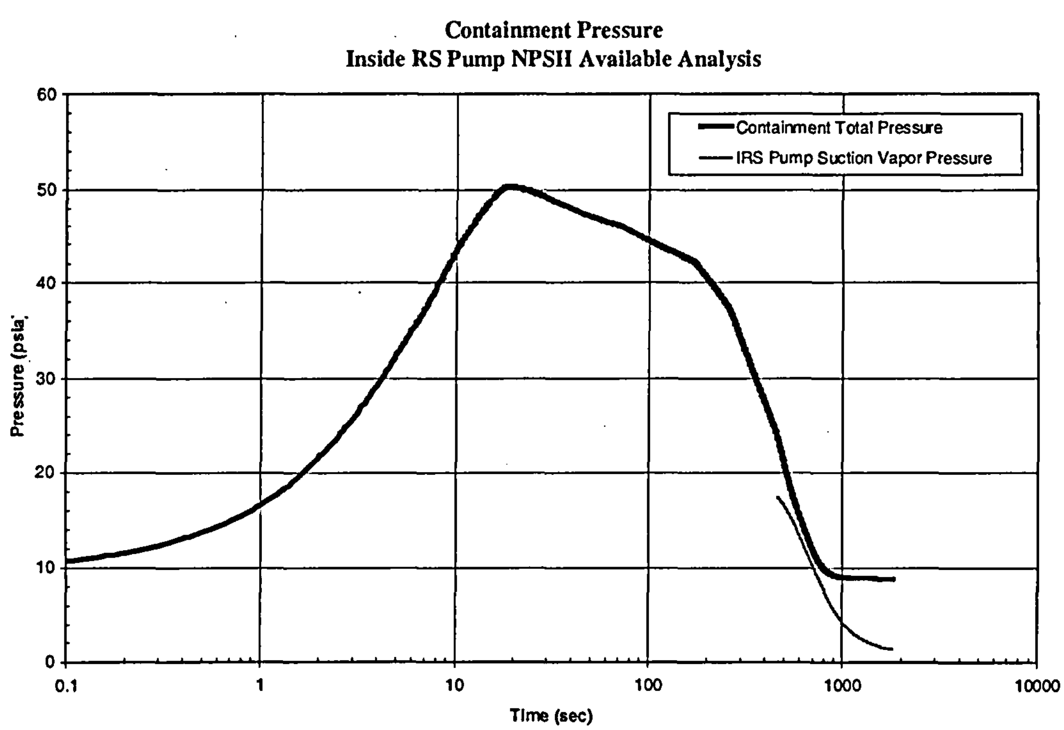


Figure 3.6-3: Containment Temperature from IRS Pump NPSHa Analysis – Current Configuration

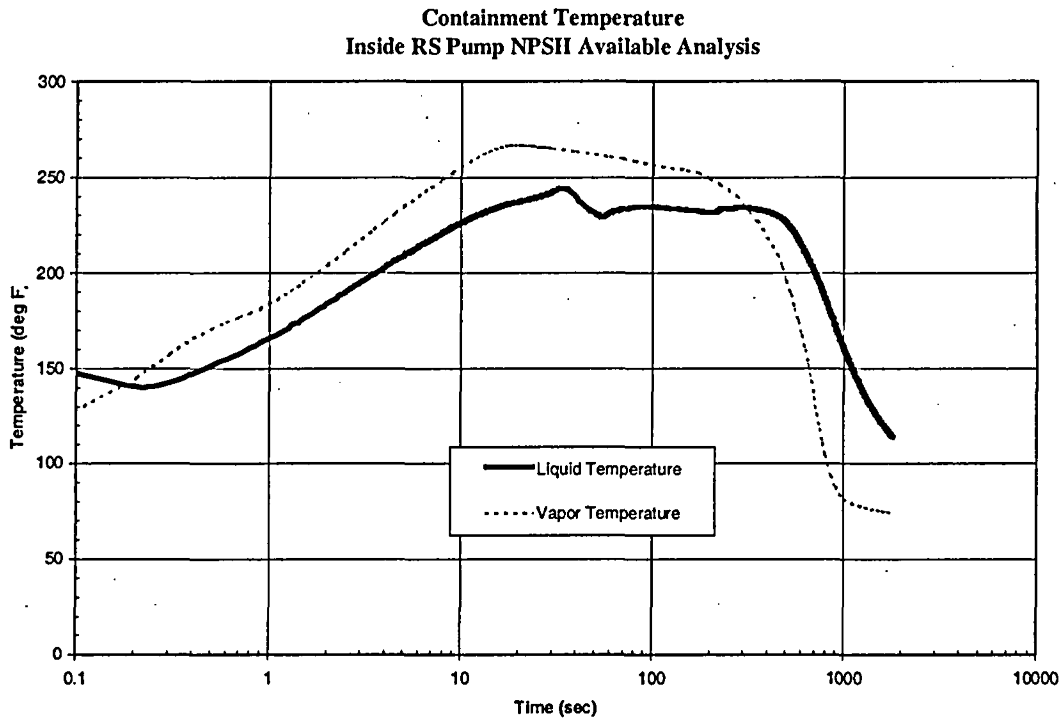


Figure 3.6-4: Total RSHX Heat Rate from IRS Pump NPSHa Analysis – Current Configuration

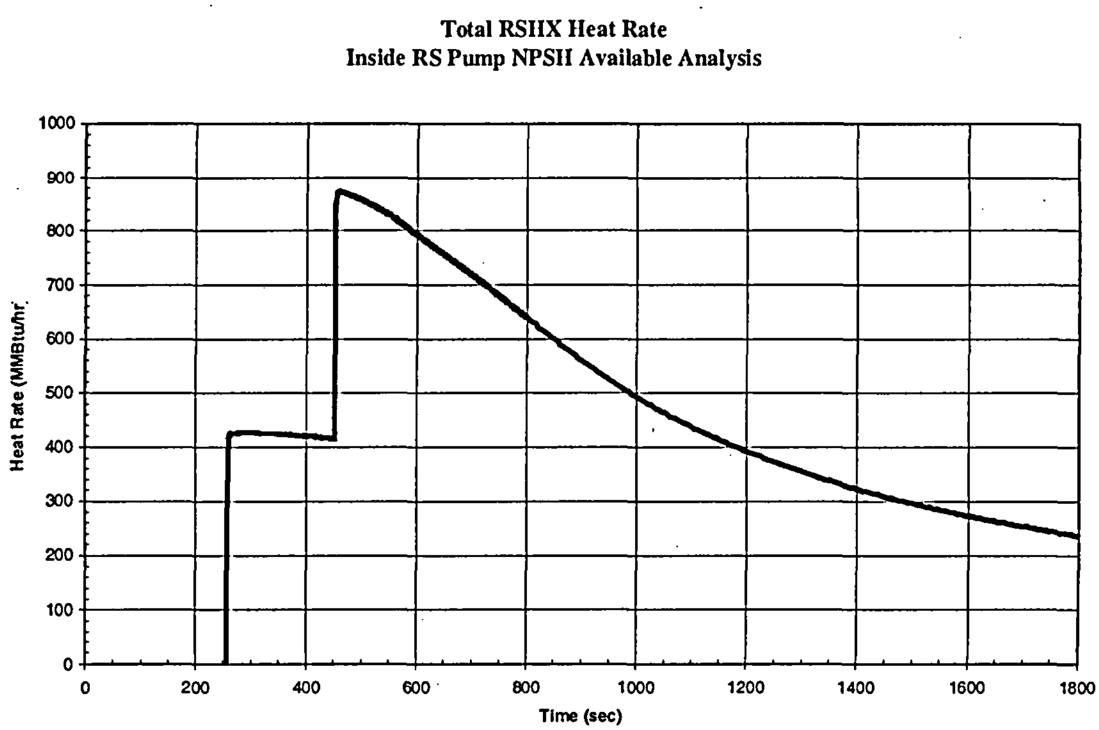


Figure 3.6-5: ORS Pump NPSHa - Current Configuration (8.85 psia, 73 F)

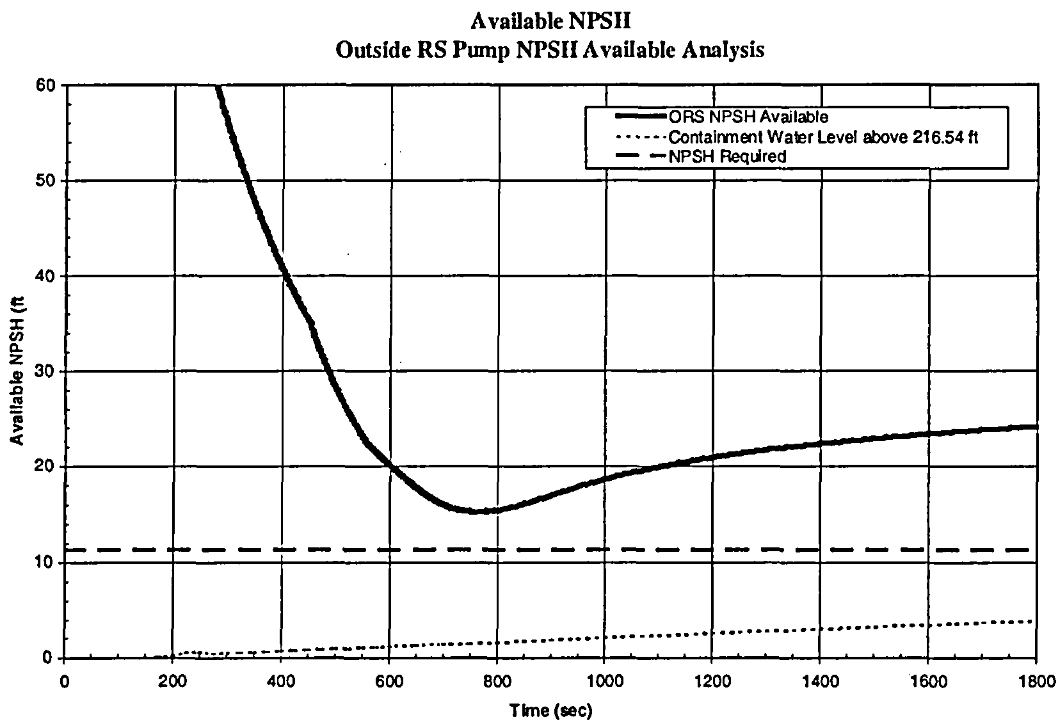


Figure 3.6-6: IRS Pump NPSHa - Proposed Configuration (10.3 psia, 35 F)

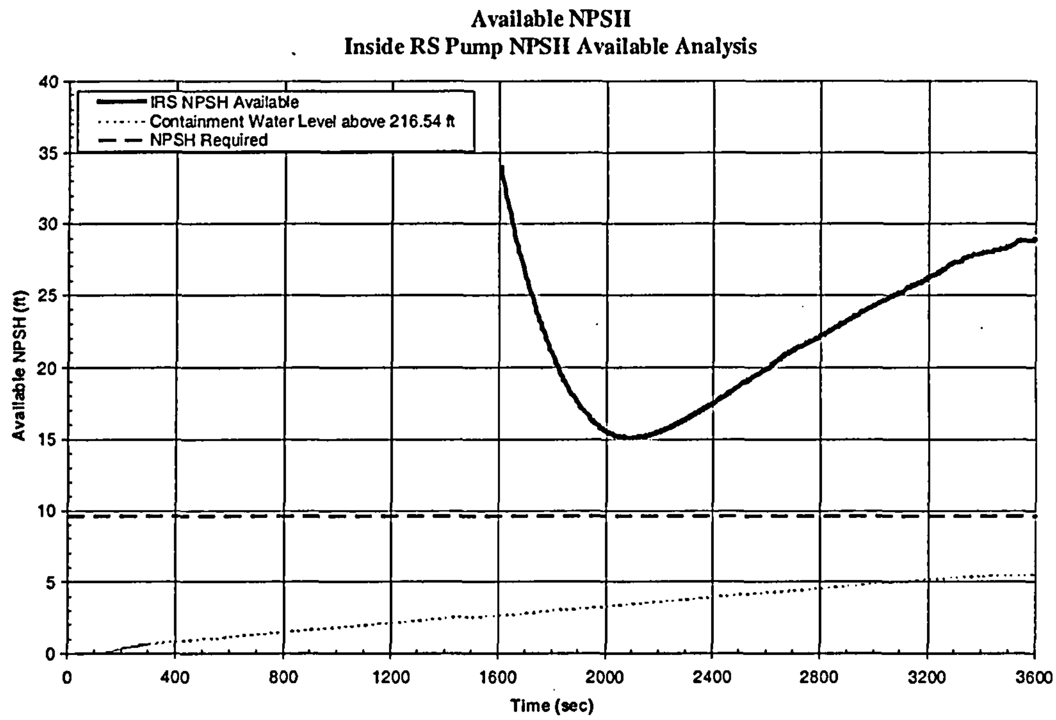


Figure 3.6-7: Containment Pressure from IRS Pump NPSHa Analysis – Proposed Configuration

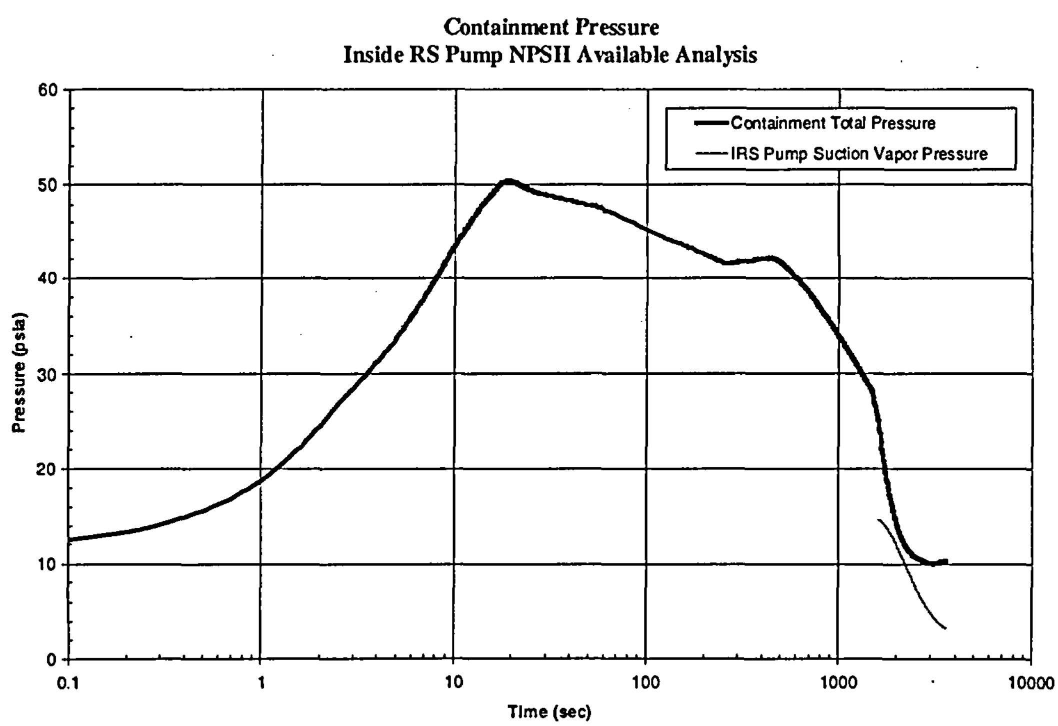


Figure 3.6-8: Containment Temperature from IRS Pump NPSHa Analysis – Proposed Configuration

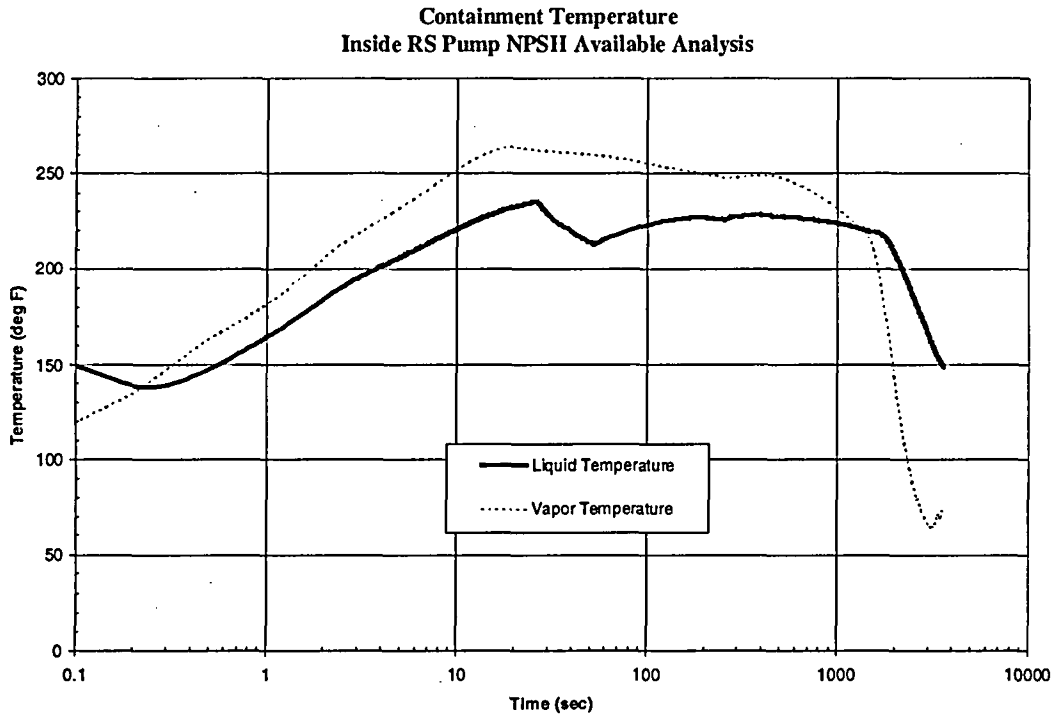


Figure 3.6-9: Total RSHX Heat Rate from IRS Pump NPSHa Analysis – Proposed Configuration

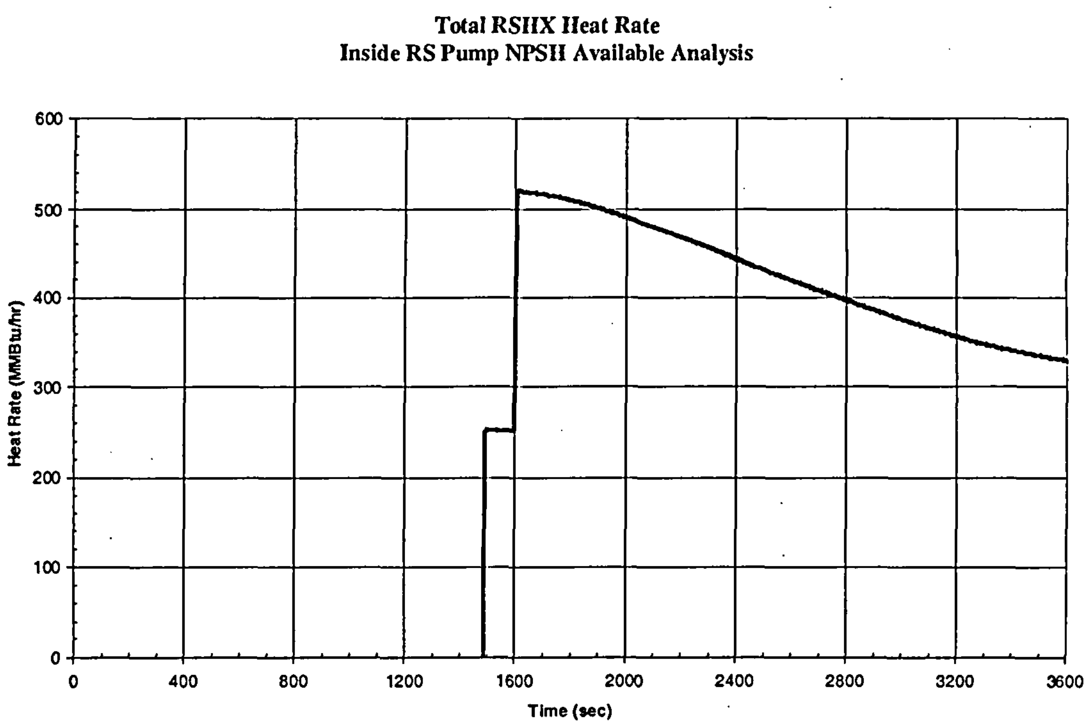


Figure 3.6-10: ORS Pump NPSHa - Proposed Configuration

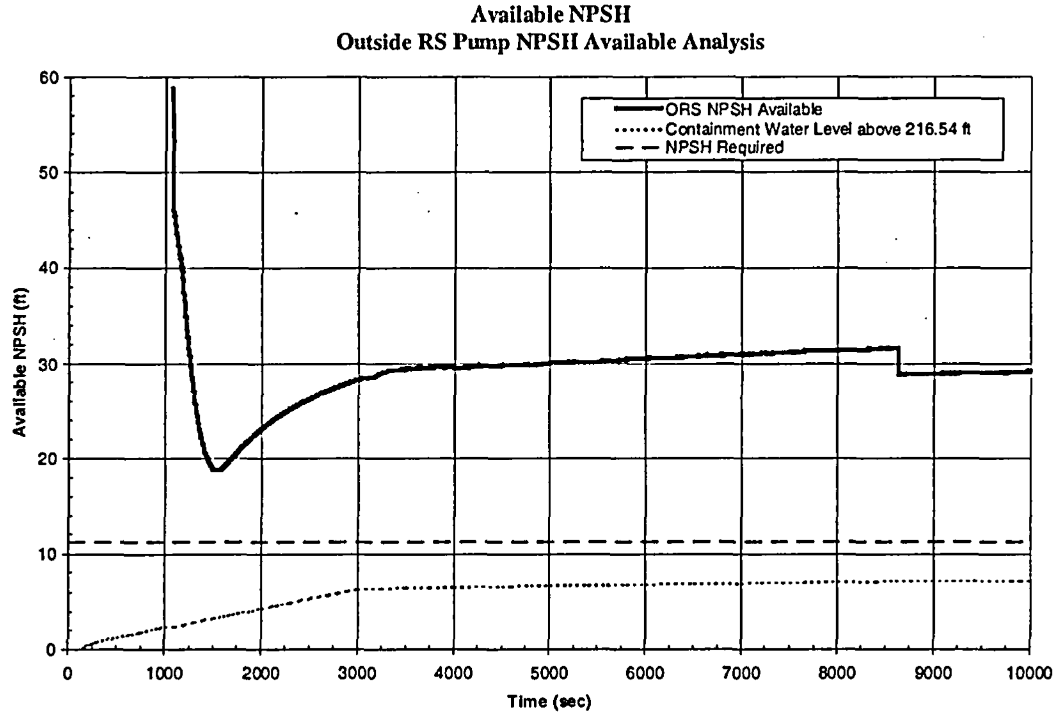


Figure 3.6-11: Containment Pressure from ORS Pump NPSHa Analysis – Proposed Configuration

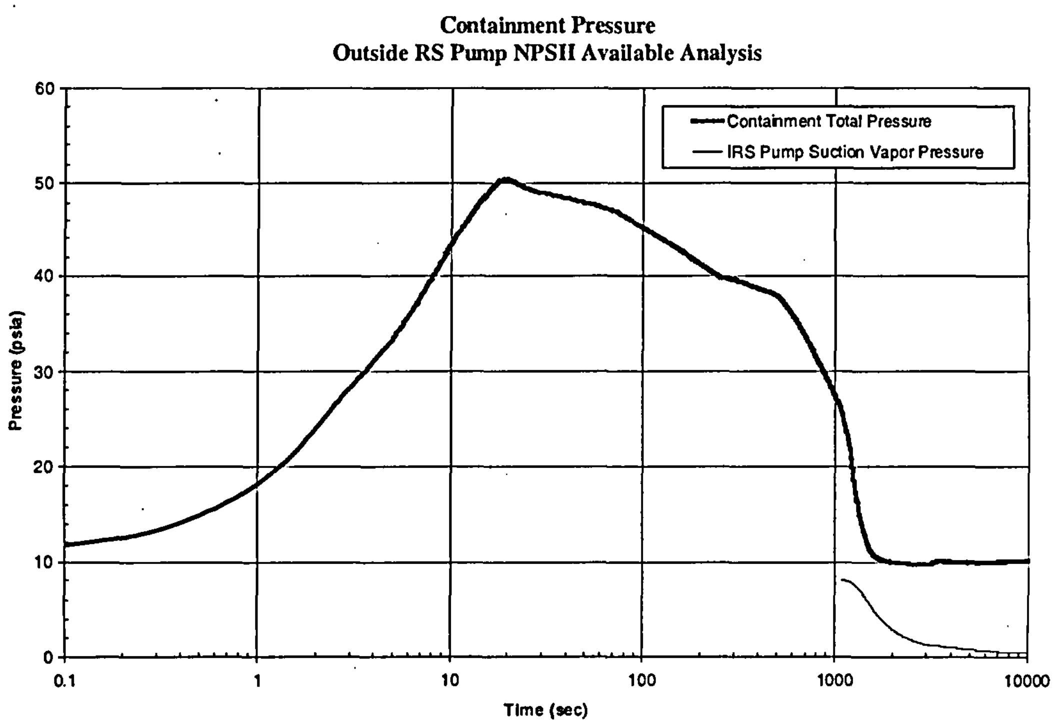


Figure 3.6-12: Containment Temperature from ORS Pump NPSHa Analysis – Proposed Configuration

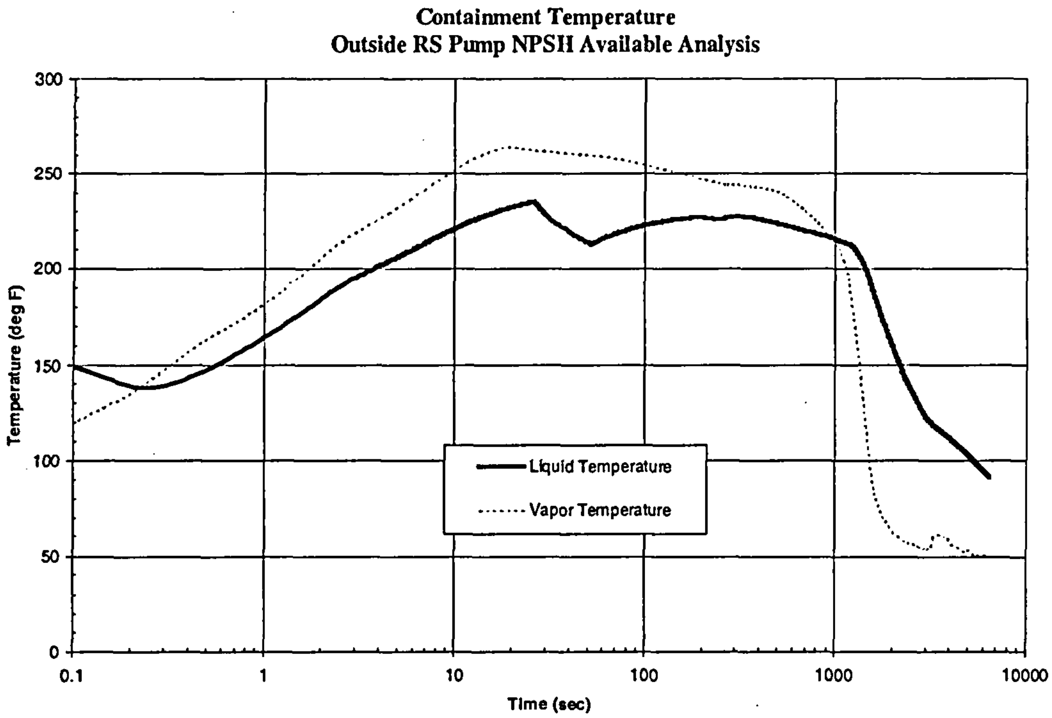
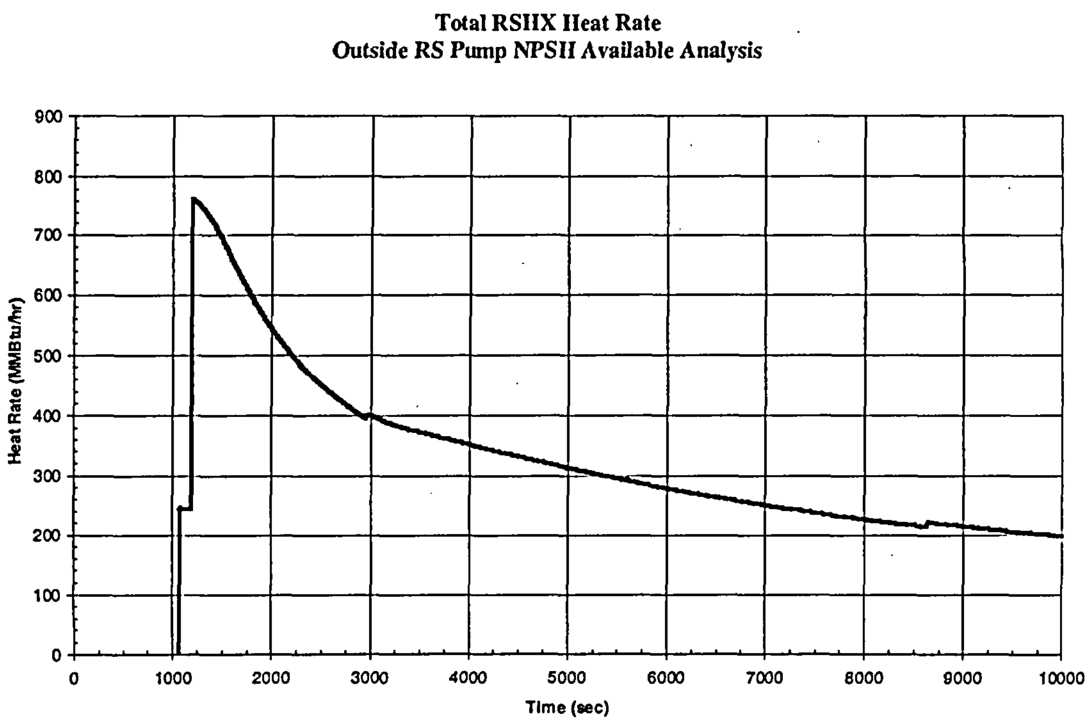


Figure 3.6-13: Total RSHX Heat Rate from ORS Pump NPSHa Analysis – Proposed Configuration



3.7 MSLB Peak Pressure and Temperature

NAPS UFSAR Section 6.2.1.3.1.2 includes LOCTIC analyses for the containment response to a MSLB event. The existing NAPS analysis of MSLB containment pressure and temperature response will be replaced with the GOTHIC calculations described in this section. GOTHIC analyses in this section do not credit the recirculation spray system. This precludes the need to demonstrate adequate RS pump performance during a MSLB event. The limiting single failure in the containment model is the loss of an emergency bus, leaving one QS pump available with minimum flow and maximum time to deliver spray to containment.

3.7.1 MSLB Peak Pressure Analysis

For the current LOCTIC analyses in the UFSAR, the maximum containment peak pressure occurs for the 1.4 ft^2 break at 0% power because it has the highest SG liquid mass and results in the largest mass release to the containment before the faulted SG dries out. The UFSAR analyses assumed that the RS system started with timer delays after containment pressure exceeded the CDA setpoint. The GOTHIC MSLB analyses do not credit RS system operation, and the limiting MSLB case changes because of the lack of RS spray flow during the accident. With the assumption of an emergency bus failure, one QS pump is the only means of reducing containment pressure until the AFW flow to the faulted SG is isolated at 30 minutes. The long-term containment pressure and temperature are dependent on the boiloff rate from the maximum AFW flow rate and the capacity of the operating QS pump.

Eleven combinations of break size and core power were analyzed to identify the peak containment pressure for the current and proposed TS maximum air pressure limits. Table 3.7-1 compares the results of the four most limiting peak pressure cases. Figure 3.7-3 compares the transient pressure profiles for eleven cases for the proposed configuration. The maximum peak pressure of 57.65 psia occurs for Case 2 (1.4 ft^2 DER at 30% power) at 1812 seconds, shortly after AFW is terminated when the remaining SG liquid mass has been boiled to the containment. Table 3.7-2 shows the time sequence of events and Figure 3.7-1 shows the containment pressure for Case 2 with the proposed TS air partial pressure limit of 12.3 psia. This limiting case is a change from the current UFSAR analyses that show the 1.4 ft^2 DER at 0% power to be limiting. This change is a direct result of not crediting the RS system. For some cases, the high AFW flow rate to the faulted SG produces a pressure peak when the last of the SG liquid inventory is boiled shortly after AFW isolation. The high AFW flows combined with the high initial mass in the SGs at low power result in the change in the limiting case by a small amount of pressure margin. This change in the limiting case without crediting the RS system was not observed in the Surry GOTHIC containment analyses due to plant differences in the AFW and spray systems. The Surry containment spray pump capacity is higher and the maximum AFW flow rate of 400 gpm (limited by cavitating venturis) to the faulted SG is less than the 900-gpm assumption for NAPS [16].

The MSLB peak pressure of 57.65 psia is 0.3 psi higher than the LOCA peak pressure in Section 3.3. The maximum initial air partial pressure is independent of SW temperature, because the RS system is not assumed to operate. Therefore, the maximum allowable TS air partial pressure is a constant line on Figure 3.10-1 until the containment depressurization analyses limit the curve (see Section 3.4). In summary, a maximum operating containment air partial pressure of 12.3 psia ensures that the MSLB peak containment pressure will be less than the design limit of 59.7 psia.

3.7.2 MSLB Peak Temperature Analysis

Nine cases were analyzed with the assumptions that maximize containment temperature during a MSLB: minimum air partial pressure, maximum containment air temperature, and 0% humidity. Analyses were performed for the current TS Figure 3.6.4-1 air partial pressure limit of 8.85 psia and the proposed TS minimum air partial pressure limit of 10.3 psia (Section 3.10). Table 3.7-3 compares the peak temperatures and Figure 3.7-4 compares the containment temperature profiles. The maximum peak temperature occurs for the 0.6 ft^2 break at 102% power (Case 6) very early in the transient. This result is consistent with the current UFSAR analyses.

The increase in air pressure causes an increase in containment peak pressure but reduces the containment peak temperature. Figure 3.7-2 shows the containment vapor temperature for the proposed configuration Case 6, where the containment temperature peaks at 31 seconds when the break flow is reduced suddenly by the isolation of the non-faulted SGs from the steam line header. The vapor temperature decrease starting at 73 seconds is driven by the delivery of quench spray to the atmosphere. Containment pressure drops rapidly once operator action terminates AFW to the faulted SG at 30 minutes.

Section 3.9 describes the evaluation for the GOTHIC-predicted superheat conditions on safety-related equipment inside containment. LOCA temperature transient results are used for post-accident equipment qualification as allowed by IE Bulletin 79-01B [18] and its supplements. Enclosure 4 to IE Bulletin 79-01B states that for a PWR MSLB inside containment, "equipment qualified for a LOCA environment is considered qualified for a MSLB environment in plants with automatic spray systems not subject to disabling single component failures." The North Anna spray systems meet this condition.

The analyses included a 1 ft^2 thermal conductor to determine a conservative containment liner temperature response in accordance with Section 3.3.3 of DOM-NAF-3. The conductor used a 1.2 multiplier on the Direct/DLM heat transfer coefficient. The peak liner temperature for the proposed configuration (case 6) was 258 F, so the sustained superheat does not adversely affect the containment liner.

Table 3.7-1: Results from MSLB Containment Peak Pressure Analyses

Case →	1	2	3	4
Steam Line Break Size, ft^2	1.4	1.4	0.707	0.4
Break Type	DER	DER	Split	DER
Core Power, % of Rated	0	30	30	30
Current Configuration*				
Peak containment pressure, psia	56.63	**57.84**	57.59	57.26
Time of peak pressure, sec	214.6	1812	1814	1825
Proposed Configuration#				
Peak containment pressure, psia	56.88	**57.65**	57.38	57.08
Time of peak pressure, sec	214.5	1812	1814	1825

* Current Configuration GOTHIC pressure is 11.7 psia TS air pressure + 0.30 psi uncertainty + 1.76 psia vapor pressure
# Proposed Configuration GOTHIC pressure is 12.3 psia TS air pressure + 0.30 psi uncertainty + 1.535 psia vapor pressure

Table 3.7-2: Time Sequence of Events from MSLB Peak Pressure Analysis – Proposed Configuration

Time reported in Seconds	Case 2
Accident start	0
CDA High High containment pressure	7
Start SI	27
QS delivered to containment	77
Faulted SG dryout	456
AFW terminated	1800
Containment peak pressure	1812
Transient Termination	7200

Table 3.7-3: Results from MSLB Containment Peak Temperature Analyses

Case →	5	6	7
Steam Line Break Size, ft^2	0.7	0.6	0.4
Break Type	DER	DER	DER
Core Power, % of Rated	102	102	30
Current Configuration*			
Peak containment temperature, F	306.2	**318.4**	298.9
Time of peak temperature, F	26.3	30.6	50.6
Proposed Configuration			
Peak containment temperature, F	296.2	**308.4**	291.9
Time of peak temperature, sec	26.4	30.8	50.6

* Current Configuration GOTHIC pressure is 8.85 psia TS air pressure - 0.30 psi uncertainty
# Proposed Configuration GOTHIC pressure is 10.3 psia TS air pressure - 0.30 psi uncertainty

Figure 3.7-1: Containment Pressure from 30% Power, 1.4 ft^2 MSLB Peak Pressure Analysis - Proposed Configuration

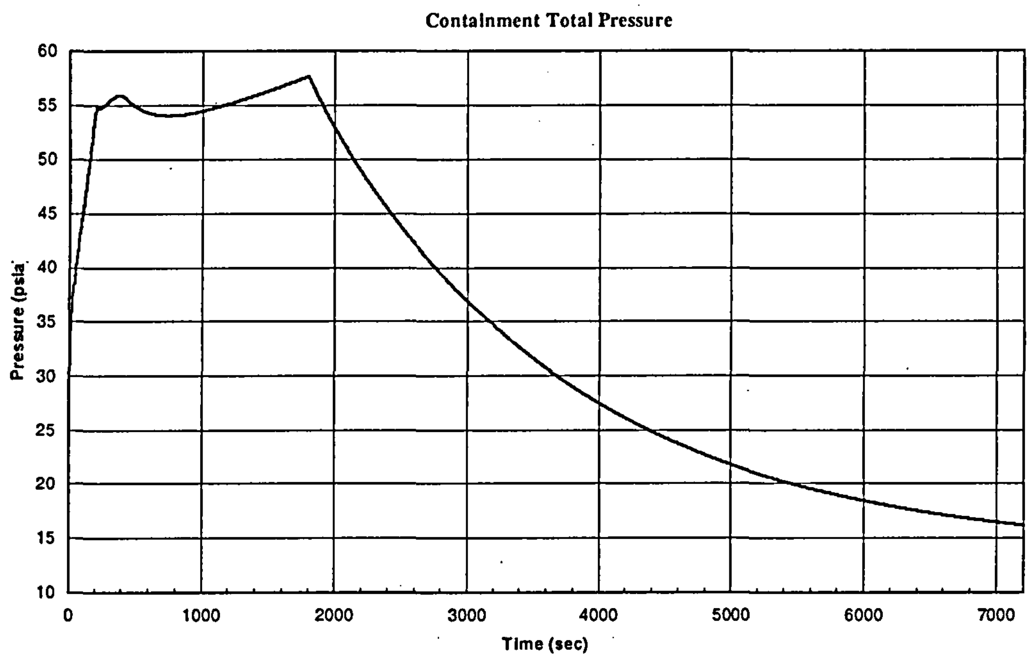


Figure 3.7-2: Containment Temperature from 102% Power, 0.6 ft^2 MSLB Peak Temperature Analysis - Proposed Configuration

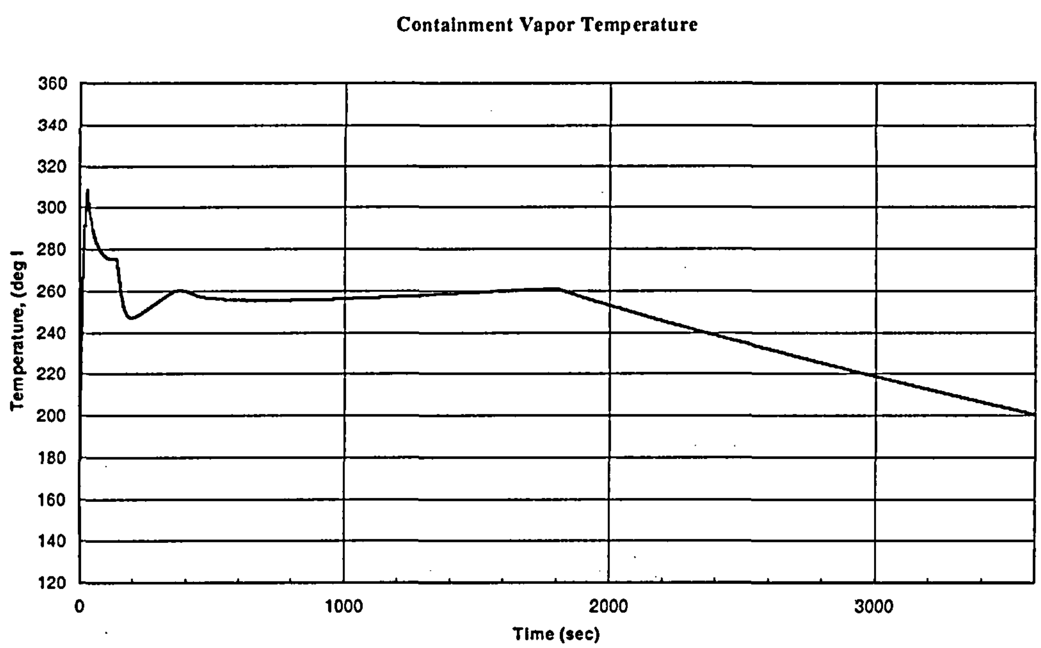


Figure 3.7-3: Containment Pressure Comparison from MSLB Peak Pressure Analyses - Proposed Configuration

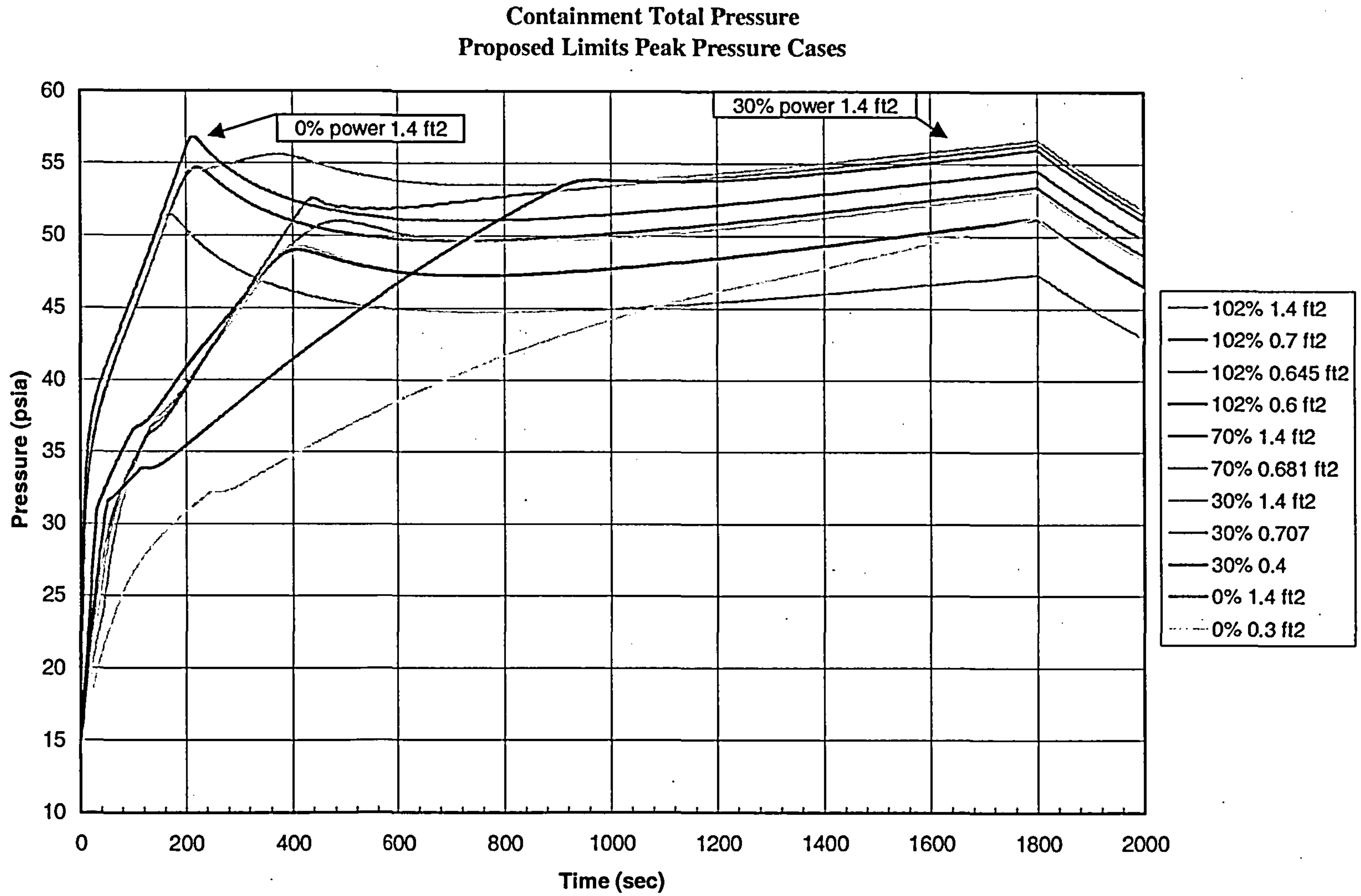
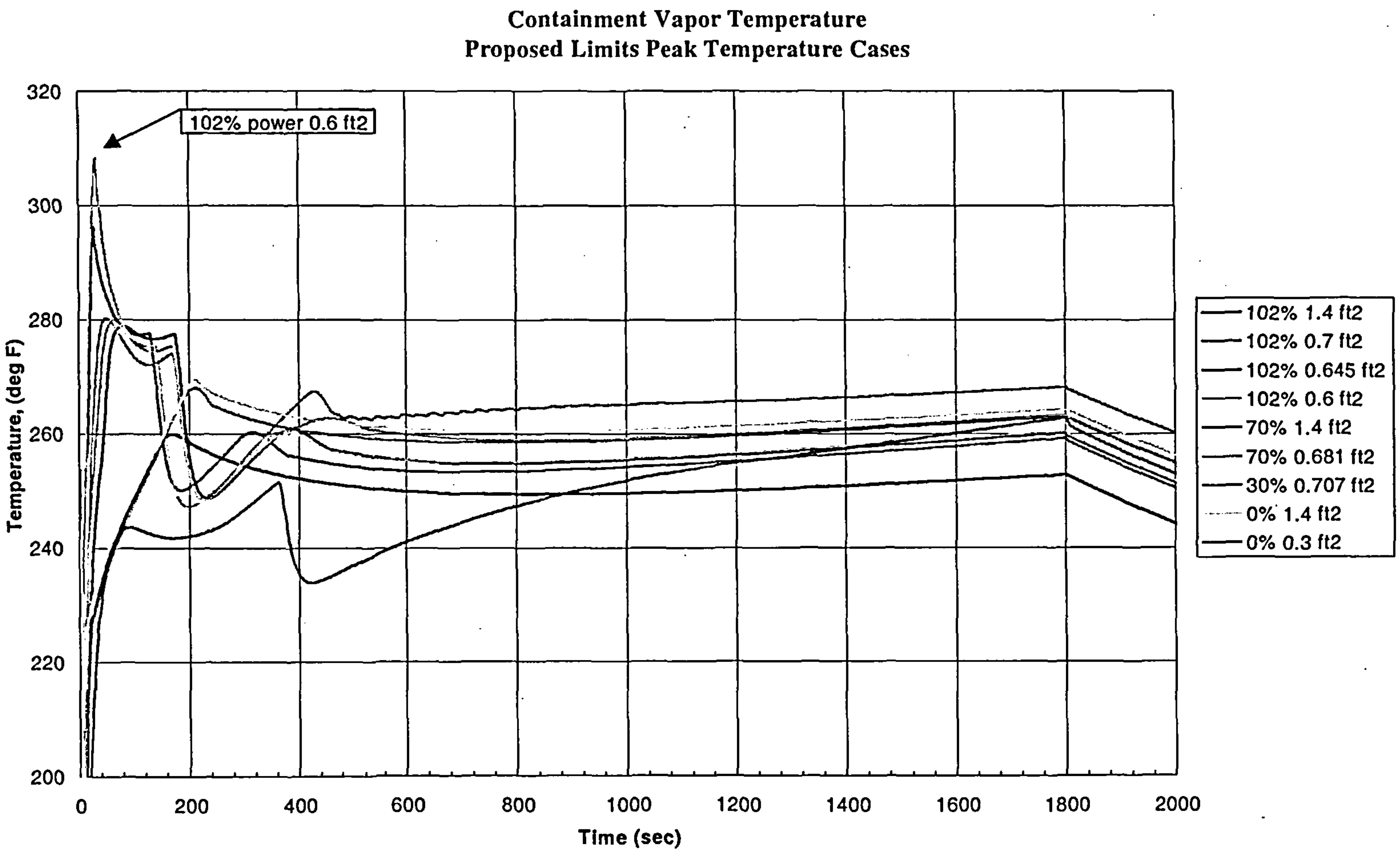


Figure 3.7-4: Comparison of MSLB Peak Temperature Analyses - Proposed Configuration



3.8 Inadvertent QS Actuation Event

NPSH calculations use the TS minimum containment air pressure as a design input. Historically, this limit has been set to provide sufficient operating margin with respect to the upper limit while balancing NPSH margin. The TS minimum limit also is an input to the event analysis for an inadvertent actuation of the quench spray system. This event is analyzed to verify three criteria from North Anna UFSAR Section 6.2.6.3. Different portions of the containment liner can withstand different minimum pressures on the inside of the liner, as follows:

1. The shell and dome plate liners are capable of withstanding an internal pressure as low as 3 psia.
2. That portion of the bottom mat liner that is covered by concrete (i.e., everywhere but the sump) can withstand an internal pressure of 5.5 psia.
3. The bottom mat liner where exposed (i.e., the sump) due to its configuration is capable of withstanding an internal pressure as low as 5.5 psia.

Section 3.10 describes how the TS lower limit on containment air partial pressure will be increased to a constant 10.3 psia. An application of the equation of state for an ideal gas (Charles' Law) used in North Anna UFSAR, Section 6.2.6.3, is repeated for the proposed TS limits. Design inputs, analysis, and conclusions are presented.

Initial Conditions

Minimum air partial pressure (P_1)	10.0 psia	TS limit of 10.3 psia – 0.3 psi uncertainty
Maximum bulk air temperature (T_1)	116.5 F	TS limit of 115.0 F + 1.5 F uncertainty
Minimum RWST temperature (T_2)	32 F	Bounding minimum value
Saturation pressure at T_2 (P_{sat})	0.09 psia	ASME Steam Tables at 32 F

Using Charles' Law for the air partial pressure (temperatures converted to Rankine), the final pressure in containment is calculated:

$$P_{total} = P_{air} + P_{vapor} = \frac{T_2}{T_1}P_1 + P_{sat}(T_2) = \frac{(460+32)(10.3-0.3)}{(460+116.5)} + 0.09 = 8.62\,\text{psia}$$

Conclusions

For an inadvertent QS actuation starting at the TS minimum air partial pressure of 10.3 psia and TS maximum air temperature of 115 F, the containment liner meets the design criteria cited above without operator action to terminate QS.

3.9 EQ Envelope Verification

Delaying the RS pump start and operating at higher containment air pressures affects the LOCA and MSLB pressure and temperature profiles. In this report, GOTHIC containment pressure and temperature profiles were generated for LOCA peak pressure (Section 3.3), MSLB peak pressure and temperature (Section 3.7), and LOCA depressurization (Section 3.4). The GOTHIC pressure and temperature profiles were not bounded by the existing environmental zone description equipment qualification (EQ) envelopes, which were based on past LOCA analysis results. Composite pressure and temperature profiles were developed that bounded the LOCA and MSLB pressure and temperature profiles from GOTHIC. The composite profiles were compared to the test reports for all environmentally qualified equipment inside containment, and it was concluded that the environmentally qualified equipment inside containment are qualified for the GOTHIC LOCA and MSLB accident analysis profiles for pressure and temperature in this report.

In conclusion, the EQ status of equipment inside containment is not affected by the GOTHIC containment temperature and pressure profiles resulting from the proposed configuration to delay RS pump start using RWST Level Low, increasing the containment air partial pressure limits in accordance with Figure 3.10-1, decreasing the containment temperature limit, and changing the RWST Level Low Low setpoint and TS allowable values for RMT.

3.10 Proposed TS Limits for Containment Air Partial Pressure vs. SW Temperature

Sections 3.3 through 3.7 describe GOTHIC containment analyses that support an increase to the TS operating domain for containment air partial pressure. This increase is possible because of the margin gain in accident peak pressure from using GOTHIC instead of LOCTIC, and because of the improved containment depressurization times with the GOTHIC methodology. A proposed change to North Anna TS Figure 3.6.4-1 is provided as Figure 3.10-1. This operating domain maintains the current limits of 35-95 F for SW temperature but reduces the maximum containment air temperature from 120 F to 115 F. Allowable limits for containment air partial pressure are defined by the following restrictions:

- The LOCA containment depressurization analyses in Section 3.4 limit the maximum operating air partial pressure to 12.3 psia at 55 F. At this same pressure, the LOCA and MSLB peak pressure analyses show margin to the containment design limit of 45 psig. Thus, the TS limit is maintained constant at 12.3 psia from 35 F to 55 F SW temperature.

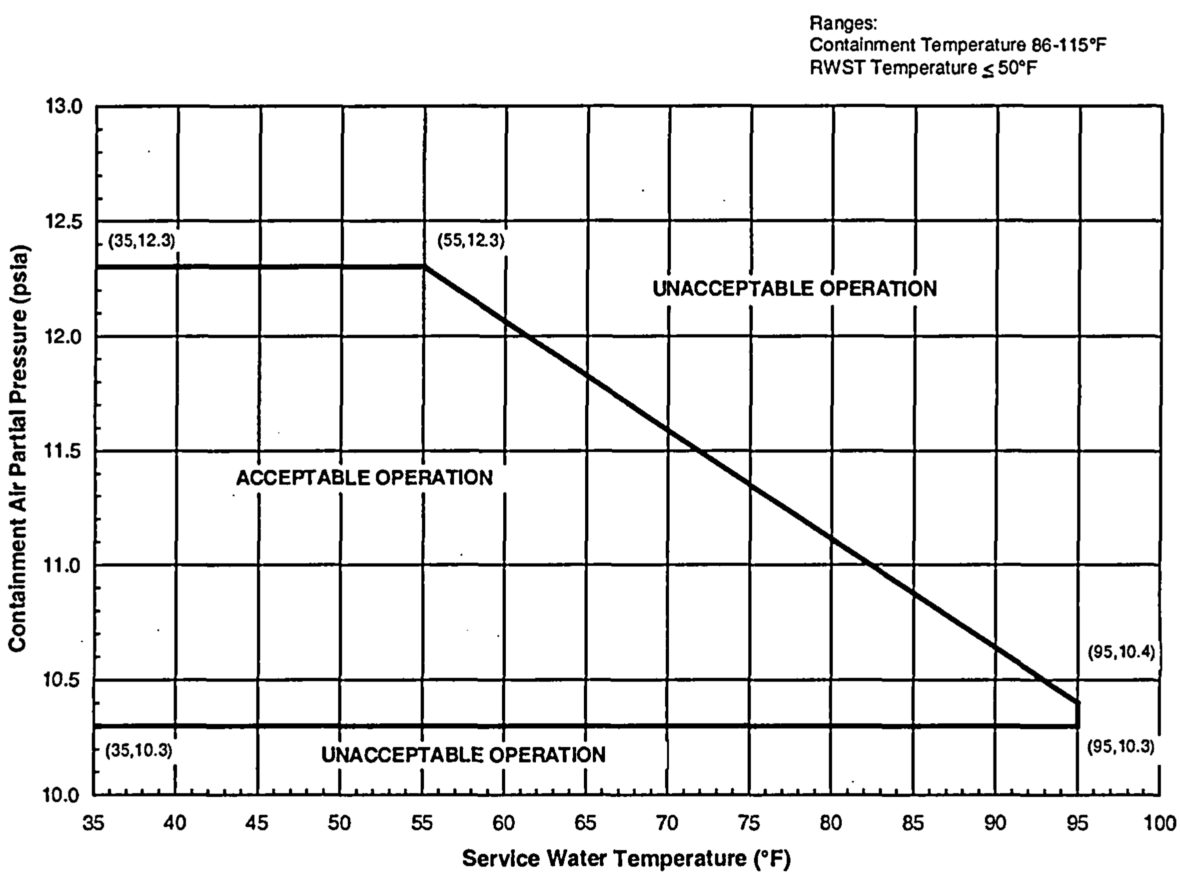
- The containment depressurization analyses in Section 3.4 set the TS upper limit from 12.3 psia at 55 F SW to 10.4 psia at 95 F SW. The allowable air pressure decreases with increasing SW temperature because it is more difficult to depressurize the containment at higher SW temperature. To meet subatmospheric requirements, the initial air partial pressure is limited to 10.4 psia at 95 F SW.

- The LHSI pump NPSH analyses set the lower limit on air partial pressure (the RS pumps use the same assumptions but have more NPSH margin). The proposed lower limit in Figure 3.10-1 ensures at least 1.5 ft of NPSH margin for the LHSI pump at recirculation mode transfer across the entire SW temperature range.

This operating domain accounts for 0.30 psi instrument uncertainty for air partial pressure. For example, the proposed configuration LOCA and MSLB peak pressure analyses assume an initial total pressure of 14.135 psia (12.30 psia TS maximum air pressure + 0.30 psi uncertainty + 1.535 psia vapor pressure at 116.5 F and 100% relative humidity).

Figure 3.10-1: Containment Air Partial Pressure versus Service Water Temperature (Proposed TS Figure 3.6.4-1)

Figure 3.6.4-1: Containment Air Partial Pressure Versus Service Water Temperature



3.11 Summary of Containment Analysis Results

Table 3.11-1 summarizes the GOTHIC containment analysis results for the current and proposed plant configurations. The results for the proposed configuration demonstrate that all containment analysis acceptance criteria are met for operation in the allowable region of Figure 3.10-1 starting the RS pumps on 60% RWST WR level coincident with High High containment pressure. Table 3.11-1 includes a LOCA containment pressure limit of 2.0 psig during the interval from 1 to 6 hours based on the revised LOCA AST analysis in Section 4 of this report. GOTHIC MSLB temperatures greater than 280 F do not adversely impact the operation of safety-related equipment inside containment. LOCA transient pressure and temperature profiles will continue to be used for post-accident equipment qualification (refer to the licensing basis in Section 3.7).

Section 4.7 of DOM-NAF-3 identified that the limiting direction of key GOTHIC inputs would be identified for each containment acceptance criterion. Table 3.11-2 documents the results of the North Anna sensitivity studies for the proposed configuration to start the RS pumps on 60% RWST level.

North Anna TS 5.5.15, Containment Leakage Rate Testing Program, requires a Type A containment integrated leak test in accordance with 10 CFR 50 Appendix J. The maximum integrated leakage rate is limited to 0.1% by weight of containment air per 24 hours at the calculated LOCA peak pressure, Pa. The most recent NAPS Type A tests initialized the containment pressure greater than 44.1 psig, the current LOCA peak containment pressure in the North Anna UFSAR and TS 5.5.15. The GOTHIC-calculated LOCA peak containment pressure is 58.4 psia (42.7 psig) for the proposed TS maximum operating air partial pressure of 12.3 psia and TS maximum containment temperature of 115 F. The GOTHIC LOCA peak pressure is less than the current UFSAR result used in the test procedure; therefore, the implementation of the change to TS Figure 3.6.4-1 is bounded by the most recent Type A tests. The value for Pa in TS 5.5.15 will be revised from 44.1 psig to 42.7 psig to be consistent with the GOTHIC LOCA containment peak pressure analysis.

Table 3.11-1: GOTHIC Containment Analysis Results

Acceptance Criterion	Design Limit	Current Configuration	Proposed Configuration
LOCA Peak Pressure	59.7 psia	56.8 psia	57.4 psia
LOCA Peak Temperature	280 F	269.8 F	269.3 F
MSLB Peak Pressure	59.7 psia	57.54 psia	57.65 psia
MSLB Peak Temperature*	280 F	318.4 F	308.4 F
Containment Depressurization Time	< 2.0 psig at 1 hour	2081 sec to < 2.0 psig#	3205 sec to < 2.0 psig
Depressurization Peak Pressure	< 2.0 psig 1-6 hours	-1.06 psig	+0.78 psig
LHSI Pump NPSH	13.4 ft at 4050 gpm	14.49 ft	14.97 ft
IRS Pump NPSH	9.6 ft at 3400 gpm	12.17 ft	15.12 ft
ORS Pump NPSH	11.3 ft at 3750 gpm	15.30 ft	18.73 ft

* Refer to Sections 3.7 and 3.9 for the disposition of superheat MSLB conditions.

This analysis is subatmospheric within 2604 seconds and remains subatmospheric thereafter.

Table 3.11-2: Matrix of Conservative Inputs for North Anna GOTHIC Containment Analyses

Note: This table is based on the proposed plant configuration to start the RS pumps on 60% RWST wide range level coincident with High-High containment pressure. Other plant modifications can change these results and require sensitivities be evaluated against the results in the table.

Table Key (also refer to the List of Acronyms and Abbreviations)
Min = Assume the **minimum** value for the range of the design input
Max = Assume the **maximum** value for the range of the design input
N/A = **Not Applicable**: the key analysis result occurs before this parameter becomes effective or the component is not part of the containment response (e.g., accumulator nitrogen does not discharge for MSLB).
N/S = **Not Sensitive**: the key analysis result is not sensitive to changes in this input parameter.

	LOCA Peak Pressure*	MSLB Peak Pressure/Temp #	Containment Depressurization	LHSI Pump NPSH	ORS Pump NPSH	IRS Pump NPSH
General						
Break Type	DEHLG	1.4 ft^2 DER for pressure 0.6 ft^2 DER for temp #	DEPSG	DEPSG	DEPSG	DEPSG
Reactor Power	102%	30% for pressure 102% for temp #	102%	102%	102%	102%
Single Failure	N/A	emergency bus	emergency bus	emergency bus	casing cooling pump	emergency bus
Containment						
Air Pressure	Max	Max / Min #	Max	Min	Min	Min
Temperature	Max	Max	Min	Max	Max	Max
Relative Humidity	100%	100% / 0% #	100%	100%	100%	100%
Free Volume	Min	Min	Min	Max	Max	Max
Heat Sink Surface Area	Min	Min	Min	Min	Min	Min

	LOCA Peak Pressure*	MSLB Peak Pressure/Temp #	Containment Depressurization	LHSI Pump NPSH	ORS Pump NPSH	IRS Pump NPSH
Safety Injection						
HHSI Injection Flow Rate	N/A	N/S	Min	Max	Min	Min
LHSI Injection Flow Rate	N/A	N/A	Min	Max	Min	Min
LHSI Recirc Flow Rate	N/A	N/A	Min	Max	N/A	N/A
LHSI Suction Piping Friction Loss	N/A	N/A	N/A	Max	N/A	N/A
Accumulator Nitrogen Pressure	N/A	N/A	Max	Min	Min	Min
Accumulator Nitrogen Volume	N/A	N/A	Max	Min	Min	Min
Accumulator Nitrogen Temperature	N/A	N/A	Min	Max	Max	Max
RWST Temperature	N/A	Max	Max	Max	Max	Max
Initial RWST Level	N/A	N/S	Max	Min	Min	Min
SI Recirc Mode Transfer	N/A	N/A	Late	Early	N/S	N/S
Quench Spray						
QS Flow Rate	N/A	Min	Min	Max	Max	Max
QS Start Time	N/A	Max	Max	Min	Min	Min
Bleed Flow to IRS Pump Suction	N/A	N/S	N/S	Min	Min	Min

	LOCA Peak Pressure*	MSLB Peak Pressure/Temp #	Containment Depressurization	LHSI Pump NPSH	ORS Pump NPSH	IRS Pump NPSH
Recirculation Spray						
RS Piping Volume	N/A	N/A	Max	Max	Max	Max
IRS Flow Rate	N/A	N/A	Min	Min	Min	Max
ORS Flow Rate	N/A	N/A	Min	Min	Max	Min
RS Pump Start on RWST Level	N/A	N/A	Late	Late	Early	Early
IRS Suction Loss	N/A	N/A	N/S	N/S	Max	Max
ORS Suction Loss	N/A	N/A	N/S	N/S	Max	Max
Casing Cooling Flow Rate	N/A	Min	Min	Min	Min	Min
Casing Cooling Tank Temperature	N/A	Max	Max	Max	Max	Max
Casing Cooling Start Time	N/A	Max	Max	Max	Max	Max
Service Water						
SW Flow Rate	N/A	N/A	Min	Min	Max	Max
SW Temperature	N/A	N/A	Max	Variable	Min	Min
HX Tube Plugging/Fouling	N/A	N/A	Max	Max	0	0

* LOCA peak pressure and temperature assumptions are the same since a saturated containment environment is maintained.

\# MSLB peak temperature occurs for small breaks and the spectrum is reviewed for any plant operating parameter changes. The peak temperature is obtained by using minimum air pressure and 0% humidity (peak pressure cases assume maximum air pressure and 100% humidity).

4.0 Revised LOCA AST Analysis

Delaying the RS pump start will result in a short-term increase in air leakage from the containment and a short-term reduction in spray removal of radioactive isotopes from the containment atmosphere. As discussed in Section 2.6, the following changes to the design basis LOCA AST analysis [References 20 and 24] that reflect the delay in RS pump start are proposed:

1) Delay in RS operation for spray removal from 288.5 seconds to 40 minutes.
2) Spray volume for QS only operation, combined QS/RS operation, and RS only operation versus 1 sprayed volume for entire period of spray operation.
3) Early ORS pump start at 14 minutes for ECCS leakage vs. 288.5 seconds in the current basis.
4) RWST backleakage is assumed to start at 31.8 minutes vs. 30 minutes in the current basis.
5) Containment leakage after the first hour of the LOCA has increased to 0.04%-volume-per-day for the time period 1 to 6 hours vs. 0.021 %-volume-per-day for the time period 1 to 4 hours in the current analysis.
6) Changes in aerosol removal coefficients due to the delay in RS operation and conservative QS flow rate assumptions.
7) Variable containment sump volume based on the containment analysis.

Other changes were made to the AST LOCA analysis to either remove conservative assumptions existing in the current analysis or changes based on a reanalysis of other parameters, including:

1) Taking credit for the 96 hour to 720 hour control room occupancy factor listed in Regulatory Guide (RG) 1.183.
2) Taking credit for the timed release of nuclides into the containment sump in accordance with RG 1.183.
3) Increase the Decontamination Factor (DF) for releases from the RWST from 10 to 40.
4) For conservatism, increase the containment volume to 1.916E+06 ft^3.
5) Increase the auxiliary building filter efficiency for organic iodines from 70% to 90% to be consistent with the Technical Specifications.
6) Increase the control room filter efficiency for organic iodines from 70% to 95% to be consistent with the Technical Specifications.
7) A slight increase in control room volume based on a recalculation.
8) The RWST "breathing rate" changed from 4 cfm to 3.7 cfm.

The remainder of the LOCA AST analysis is unchanged from Section 3.1 of Attachment 1 to Reference 24. The unchanged assumptions include the following:

1) The source term and core power are unchanged.
2) The EAB, LPZ, and control room X/Q's are unchanged.
3) The dose conversion factors are consistent with Federal Guidance Reports 11 and 12.
4) The core release fractions and phases are consistent with RG 1.183
5) The chemical form of the iodines released from the fuel and also found in the sump is consistent with RG 1.183.
6) The modeling of elemental iodine spray removal is unchanged ($\lambda = 10\ hr^{-1}$, cutoff at 2.33 hrs).
7) The off-site and control room breathing rates are consistent with RG 1.183.
8) The sump pH > 7 when RS is credited for iodine removal.
9) No credit is taken for removal of organic iodines by sprays nor any forms of iodines by deposition.
10) The control room is isolated at t=0 hours post-LOCA from a safety injection (SI) signal.
11) The control room unfiltered inleakage rate is 250 cfm. This is supported by tracer gas testing, which resulted in 150 cfm inleakage in a non-pressurized alignment of the control room.
12) One emergency control room fan is aligned to pressurize the control room with 900 cfm of filtered outside air at 60 minutes after the control room is isolated. Unfiltered inleakage of 250 cfm remains constant even during pressurization.
13) Control room filtered recirculation flow is not credited.
14) No credit is taken for the MCR bottle air system.
15) The flash fraction for iodines in the ECCS leakage analysis is consistent with RG 1.183 at 10%.
16) Auxiliary Building filtration (PREACS) is aligned at 1 hour post-LOCA, ensuring ECCS leakage into area serviced by this system is filtered at 1 hour post-LOCA.
17) ECCS leakage was modeled using different scenarios. They ranged from up to 3,400 cc/hr of only unfiltered leakage, 34,400 cc/hr of only filtered leakage, and combinations of both. The limiting leakage scenario is 3,400 cc/hr of unfiltered ECCS leakage. The allowable leakage limits are one-half of the analysis amounts per RG 1.183.
18) RWST backleakage rate is 2,400 cc/hr. The limit will be one-half of the analysis amount per RG 1.183.
19) The PREACS and control room filter efficiencies for aerosols and elemental iodines remained at 98% and 95% respectively.

4.1 Changes in Containment Pressure and Leakage Assumptions

In the current AST LOCA analysis the containment leak rate is modeled for the first hour at the peak pressure technical specification leak rate of 0.1% of the containment volume per day in accordance with RG 1.183. For the next 3 hours after the LOCA, the current design basis analysis models the leakage at 0.021% volume per day assuming a pressure of 0.5 psig. Containment leakage is modeled as terminating at 4 hours based on containment attaining subatmospheric conditions.

In the revised design basis models the containment leak rate for the first hour remains at 0.1% of the containment volume per day. After the first hour, the containment leakage is conservatively modeled at 0.04% volumes per day, assuming a pressure of 2.0 psig, with leakage terminating after the sixth hour. This pressure profile bound the LOCA depressurization analyses described in Section 3.4. Table 4.1-1 summarizes the current and proposed containment pressure and leakage assumptions.

Table 4.1-1: Containment Leak Rate Assumption

Current Time Period	Current Containment Pressure Assumption	Current Containment Leak Rate Assumption	Revised Time Period	Revised Containment Pressure Assumption	Revised Containment Leak Rate Assumption
0-1 hours	Decreasing to 0.5 psig	0.1 %/day	0-1 hours	Decreasing to 2.0 psig	0.1 %/day
1-4 hours	0.5 psig	0.021 %/day	1-6 hours	2.0 psig	0.04 %/day
> 4 hours	Subatmospheric	0.0	> 6 hours	Subatmospheric	0.0

4.2 Description of Containment Volumes

The containment free volume is 1.916E+06 ft^3 and the cross sectional area at the operating deck is 1.247E4 ft^2. The containment free volume is an increase over that value reported in Reference 24, which is conservative for this analysis. For the first 40 minutes, only QS is operating. From 40 minutes to 1.5 hours both QS and RS are operating and after 1.5 hours only RS is operating. Table 4.2-1 lists the volumes for the sprayed and unsprayed regions based on these times. The current analysis assumes a constant 70% sprayed volume starting at 90 seconds. The mixing rate of 2 times the unsprayed volume per hour was adjusted to reflect the volumes and times listed in Table 4.2-1. For conservatism the times listed in Table 4.2.1 reflect a further delay of the start of RS and an earlier termination of QS than those determined in the containment analysis.

Table 4.2-1: Time Dependent Sprayed/Unsprayed Containment Fractions

Time Period	Percent Sprayed	Volume Sprayed (ft^3)	Percent Unsprayed	Volume Unsprayed (ft^3)
73 seconds – 40 minutes	37.6%	7.204E+05	62.4%	1.196E+06
40 minutes – 1.5 hours	83.8%	1.606E+06	16.2%	3.104E+05
1.5 – 6 hours	73.1%	1.401E+06	26.9%	5.154E+05

The RADTRAD computer code modeled the sprayed volume and unsprayed volume as variable volumes using the values listed in Table 4.2-1. However the source term fraction can only be modeled as a single value in RADTRAD. To accurately reflect the source term fraction released simultaneously into the varying sprayed and unsprayed volumes a weighted average model was used. This model takes into account the size of the sprayed region and the period of time that the coverage existed. Since the source term is released over 1.8 hours post-LOCA, the final time period of RS only coverage is from 1.5 hours to 1.8 hours. The weighted average is calculated based upon the total core release period of 1.8 hours, the 3 time periods of spray operation, and the percent sprayed regions during those periods.

$$\text{Weighted Average} = \frac{(0.67\text{ hrs. x }0.376) + (0.83\text{ hrs. x }0.838) + (0.3\text{ hrs. x }0.731)}{1.8\text{ hrs}}$$

This methodology results in a source term fraction of 64.8% in the sprayed region. The source term fraction released into the sprayed volume is conservatively rounded down to 0.64. The remaining, or 0.36, is released into the unsprayed volume.

4.3 Changes in Containment Spray Removal Coefficients

With the delay in the start of the RS pumps, new aerosol removal coefficients were calculated using the same methodology as described in Reference 24. In this analysis QS start time is 73 seconds and termination is conservatively assumed at 1.5 hours. Both ORS and IRS are conservatively assumed to start at 40 minutes.

Table 4.3-1 presents the characteristics of the QS and RS systems. The QS flow rates in Table 4.3-1 represent a decrease from the values presented in Reference 24. The QS flow rates used are conservatively assumed at 100 gpm lower than the flow rate values determined from the GOTHIC LOCA depressurization analyses in Section 3.4.

Table 4.3-1: Spray System Characteristics

QS	IRS	ORS
Elevation 391'-10" & 393'-2"	Elevation: 377'-10"	Elevation: 376'-10"
1400 gpm (73 – 2000 sec)	3450 gpm @ 40 minutes	3100 gpm @ 40 minutes
1500 gpm (2000 – 3000 sec)		
1600 gpm (3000 – 5000 sec)		
1500 gpm (5000 – 5400 sec)		

The current and revised spray aerosol removal coefficients are calculated using the equations given in NUREG/CR-5966. Table 4.3-2 contains the existing aerosol removal coefficients. Revised aerosol removal coefficients were developed as discussed below.

Table 4.3-2: Current Combined QS and RS Aerosol Removal Coefficients[1]

Time (hours)		Removal Coefficient (hr^{-1})
From	To	
2.50E-02	8.01E-02	3.7267E+00
8.01E-02	1.33E-01	1.0799E+01
1.33E-01	1.56E+00	1.6672E+01
1.56E+00	1.80E+00	1.2528E+01
1.80E+00	1.87E+00	7.9863E+00
1.87E+00	1.97E+00	5.5782E+00
1.97E+00	2.33E+00	2.9768E+00
2.33E+00	3.76E+00	1.6191E+00
3.76E+00	5.35E+00	1.4460E+00
5.35E+00	6.97E+00	1.4239E+00
6.97E+00	8.59E+00	1.4211E+00
8.59E+00	1.61E+02	1.4207E+00

1. Table 3.1-5 of Reference 24 and Table 15.4-6 of the UFSAR

NUREG/CR-5966 [Page 173] presents the following equations for aerosol removal rate for the 10th percentile level:

$$\ln\left(\lambda_{m_f=0.9}\right) = 5.5750 + (0.94362)\ln Q - (7.327\text{E}-7)QH^2 - (6.9821\text{E}-3)Q^2H + (3.555\text{E}-6)Q^2H^2$$

$$\frac{\lambda_{m_f}}{\lambda_{m_f=0.9}} = [0.1108 - (0.00201)\log_{10} Q]\left[1 - \left(\frac{m_f}{0.9}\right)^{0.8945}\right] + \left(\frac{m_f}{0.9}\right)^{0.8945}$$

where λ is the removal rate, m_f is the mass fraction remaining in the containment, H is the spray drop height, and Q is the spray water flux, calculated by dividing the spray flow rate by the wetted cross-sectional area of the sprayed portion of the containment. The wetted cross-sectional area is determined by multiplying the containment cross-sectional area (1.247 ft^2) by the sprayed fraction (percent sprayed from Table 4.2-1 divided by 100). The first equation above is used to calculate the removal rate corresponding to a mass fraction of 0.9. Using this value into the second equation yields the removal for a given value of mass fraction. Since the removal rate is dependent on drop height and spray rate, the spray headers have different removal rates.

The drop heights and spray flux are calculated using input from Tables 4.2-1 and 4.3-1. Spray flux is derived as follows:
Q = (Spray Flow (t) gpm) (0.13368 ft^3/gal) / (1.247E4 ft^2) / (sprayed fraction (t)) (30.48 cm/ft) / (60 sec/min)

Table 4.3-1 presents the QS and RS system characteristics using the 291'-10" elevation of the operating deck to determine the drop height. To simplify the modeling of the QS headers, both the upper and lower headers are modeled at the elevation of the lowest header or 391'-10" resulting in a drop height of 3048 cm. The 4 RS headers are modeled at the average elevation of the RS headers or 377'-4" resulting in a drop height of 2606 cm. This is appropriate since 1 train of IRS/ORS operating together supply water to both elevations.

When QS and RS are operating together a weighted average, based on flow rates, of the different elevations are used to calculate the drop height. A high QS flow rate is used for conservatism.

IRS (H) = (377'-10") – (291'-10") = 86 ft = 2621 cm
ORS (H) = (376'-10") – (291'10") = 85 ft = 2591 cm

$$H = \frac{QS\ (3048\ cm)(1800\ gpm) + IRS\ (2621\ cm)(3450\ gpm) + ORS\ (2591\ cm)(3100\ gpm)}{8350\ gpm}$$

H = 2702 cm during QS and RS operation

NUREG/CR-5966 [Page 170] recommends that for a volume with continuing source, the removal constant associated with a mass fraction of 0.9 be used until the time-dependent source terminates. Hence, the mass fraction is assumed to remain at 0.9 from the start of the sprays until the end of the early in-vessel release phase at 1.8 hr. After this phase, the removal rate is adjusted stepwise by varying the mass fraction. The duration of time, t, required to change from a mass fraction m_{f0} to m_{f1} is determined using the following formula:

$$m_{f1} = m_{f0}e^{-\lambda t}$$
$$t = \ln(m_{f0}/m_{f1})/\lambda$$

For example, as seen in Table 4.3-3, it takes 0.08 hr (1.80 to 1.88 hr) to reduce the iodine mass fraction from 0.9 to 0.5. During this time step, the removal rate is constant at 7.739 hr^{-1}.

Table 4.3-3 lists the data and aerosol removal coefficients for QS only operation, QS and RS operating simultaneously, and RS only operation.

Table 4.3-3: Aerosol Removal Coefficients

	Q	H	Removal Constant (hr^{-1})			Time (hr)	
m_f	(cm/sec)	(cm)	$\lambda_{mf=.9}$	$\lambda_{mf}/\lambda_{mf=.9}$	λ_{mf}	From	To
Aerosol Quench Spray Only Removal Coefficients							
9.00E-01	2.028E-02	3048	5.832E+00	1.00E+00	5.832E+00	2.03E-02	5.56E-01
9.00E-01	2.172E-02	3048	6.167E+00	1.00E+00	6.167E+00	5.56E-01	6.67E-01
Aerosol Quench and Recirc Spray Removal Coefficients							
9.00E-01	5.231E-02	2702	1.256E+01	1.00E+00	1.256E+01	6.67E-01	8.33E-01
9.00E-01	5.296E-02	2702	1.267E+01	1.00E+00	1.267E+01	8.33E-01	1.11E+00
9.00E-01	5.296E-02	2702	1.267E+01	1.00E+00	1.267E+01	1.11E+00	1.39E+00
9.00E-01	5.231E-02	2702	1.256E+01	1.00E+00	1.256E+01	1.39E+00	1.50E+00
Aerosol Recirc Spray Only Removal Coefficients							
9.00E-01	4.88E-02	2606	1.214E+01	1.00E+00	1.214E+01	1.50E+00	1.80E+00
5.00E-01	4.88E-02	2606	1.214E+01	6.375E-01	7.739E+00	1.80E+00	1.88E+00
3.00E-01	4.88E-02	2606	1.214E+01	4.453E-01	5.406E+00	1.88E+00	1.97E+00
1.00E-01	4.88E-02	2606	1.214E+01	2.376E-01	2.885E+00	1.97E+00	2.35E+00
1.00E-02	4.88E-02	2606	1.214E+01	1.293E-01	1.569E+00	2.35E+00	3.82E+00
1.00E-03	4.88E-02	2606	1.214E+01	1.155E-01	1.402E+00	3.82E+00	5.46E+00
1.00E-04	4.88E-02	2606	1.214E+01	1.137E-01	1.380E+00	5.46E+00	7.13E+00

In the RADTRAD computer runs, which are limited to 10 values for aerosol spray removal coefficients, the removal coefficient at 6.67E-01 hours, the assumed start of RS, will remain constant at 1.256E+01 per hour until 1.5E+00 hours, the assumed end of QS. This is a conservative assumption as it can be seen in Table 4.3-3 that the removal coefficient increases during this time period.

4.4 Changes in ECCS Leakage Assumptions

The delay in RS actuation results in a delay of the start of ECCS leakage. An early RS start for ECCS leakage results in a more conservative dose. Therefore, RS is assumed to start at 14 minutes instead of the 40 minutes assumed in the containment release. In the current analysis, ECCS leakage starts at 288.5 seconds [24].

Another change to the ECCS leakage analysis is in the modeling the containment sump volume as a variable volume in RADTRAD based on the GOTHIC analysis. A lower sump volume results in a higher dose due to less dilution volume. Therefore, the volumes reported by GOTHIC were reduced by 10% for conservatism. Table 4.4-1 lists the sump volume versus time used in the ECCS leakage analysis.

Table 4.4-1: Containment Sump Volume vs. Time

Time (seconds)	Sump Volume (ft^3)
840	16,800
1500	25,700
1900	31,400
2500	39,900
3000	46,800
4000	60,000
5000	68,800
6000	73,200
8000	76,000

4.5 Changes in RWST Leakage Assumptions

As with the ECCS leakage analysis the containment sump volume is modeled as a variable volume in RADTRAD based on the GOTHIC analysis. A lower sump volume results in a higher dose due to less dilution volume. Therefore the volumes listed in Table 4.4-1 are also used in the RWST backleakage analysis. The start of RWST backleakage, which is the start of RMT, is consistent with the GOTHIC analysis at 31.8 minutes.

The breathing rate used in Reference 24 for the RWST release was 4 cfm, whereas the RWST breathing rate used in this analysis was 3.7 cfm. The analysis that supports Reference 24 calculated 3.7 cfm as the RWST breathing rate but rounded it up to 4 cfm for conservatism. This analysis uses the actual value calculated of 3.7 cfm.

The partition coefficient (PC) applicable to the iodines in the RWST water is based upon information in Reference 21. For this application, the RWST was assumed to behave like a closed system for the establishment of equilibrium conditions between the water and air. This is appropriate during the cooldown phase when air that is drawn into the RWST inhibits the loss of airborne iodine. It is also appropriate during the heat-up phase as the change in air volume is small and any impact on equilibrium conditions is therefore minimal.

The critical factor in the magnitude of the partition coefficient (PC) for iodines is the total iodine concentration in the water. For this application it was first necessary to compute the iodine concentration in the RWST. The ORIGENARP routine of SCALE calculated the total quantity of iodine in the core at 19,110 grams, which was conservatively rounded to 20,000 grams. The fraction of iodines released during the LOCA is 0.4, resulting in the containment sump containing 8,000 grams of iodine. The volume of liquid in the sump at the start of RWST backleakage is 31,400 ft^3 (Table 4.4-1) or 234,900 gallons. The analysis of PC conservatively ignores the increasing sump volume, which results in a lower concentration of iodines in the sump. The analysis of the PC also conservatively ignores the timing of the release into the sump over the 1.8 hours. Therefore, the maximum iodine concentration in the sump is 34 mgrams/gallon. The backleakage rate of 2400 cc/hr remains unchanged from Reference 24. Total sump liquid transferred to the RWST over 30 days as a result of backleakage is 457 gallons, resulting in a total of 15,560 mgrams of iodine transferred to the RWST.

Adding the 457 gallons, as a result of backleakage, to the minimum volume in the RWST at the end of the injection phase (16,780 gallons) results in a total volume in the RWST at the end of the 30 days of 17,240 gallons. Because the volume of water in the RWST is free of iodine, the concentration of iodine in the RWST increases over time and the maximum occurs at the end of the 30 days. Therefore the maximum concentration of iodine in the RWST is 0.9 mgrams/gallon or approximately 0.3 mgrams/liter.

At the maximum iodine concentration in the RWST, the partition coefficient (PC) and Decontamination Factor (DF) will be at a minimum. For conservatism, the DF at the end of 30 days will be used for the entire RWST backleakage period. The PC corresponding to the iodine concentration of 0.3 mgrams/liter is taken from Reference 21. Using the top curve, the PC is approximately 6000. The DF is calculated using the equation from SRP 6.5.2 and is:

$$DF = 1 + (Vliquid / Vair) * PC$$

where

Vliquid and Vair are the volumes in the RWST between which the partitioning takes place

The RWST liquid volume at the end of 30 days is 17,240 gallons. The maximum RWST capacity is 509,900 gallons, resulting in an air volume at the end of 30 days of 492,600 gallons. The resulting DF is 211. The analysis conservatively uses a DF of 40.

4.6 Changes in Control Room Occupancy Factors

Credit is being taken for the control room occupancy factors listed in RG 1.183. In Reference 24, the occupancy factor for the 96-hour to 720-hour time period was conservatively assumed at 0.6. In the new analysis, the occupancy factor for that time period is 0.4, consistent with RG 1.183.

4.7 Timing of Release Phases

The ECCS and RWST analyses from Reference 24 assumed that 40% of the core iodines were instantaneously transported from the core to the containment sump. The new analysis takes credit for the timed release of iodines into the sump as allowed by RG 1.183. The timed release of iodines in the sump is modeled as 5% for the first 30 minutes and 35% for the next 1.3 hours.

4.8 Control Room and Auxiliary Building Filter Efficiency

In Reference 24 the control room and auxiliary building filter efficiency for organic iodines was conservatively modeled at 70%. In the new analysis the organic filter efficiency for the control room is modeled at 95% and the auxiliary building at 90%. These values are consistent with the North Anna Technical Specifications.

4.9 Control Room Volume

The North Anna control room volume used in the analysis was recalculated to be 7.910E+04 ft^3. This volume is a slight increase from 7.70E+04 ft^3, which was used in Reference 24, but still remains a conservative value. The volume only includes the control room and the battery rooms minus a 10% conservative assumption and does not include other areas of the control room envelope.

4.10 Revised Radiological Results

Table 4.10-1 presents the revised design basis LOCA radiological dose results with the changes in assumptions as described in Sections 4.1 through 4.9. The analysis results are less than the regulatory dose limits.

Table 4.10-1: Revised Design Basis LOCA Dose Results

	Control Room (Rem TEDE)	Exclusion Area Boundary (Rem TEDE)	Low Population Zone (Rem TEDE)
Total Dose Consequences including contributions from containment, ECCS and RWST leakage	4.1	2.1	0.2
10 CFR 50.67 dose limits	5	25	25

5.0 Conclusions

This technical report demonstrates that the proposed safety analysis acceptance criteria are satisfied for the plant licensing basis changes outlined in Section 2. The specific changes for North Anna Power Station are:

- Start ORS pumps on 60% RWST WR level coincident with High High containment pressure
- Start IRS pumps on 60% RWST WR level coincident with High High containment pressure plus 120-second delay time
- Incorporate the instrumentation and surveillance requirements for the RWST Level Low ESF function for RS pump start into the Technical Specifications.
- Replace the containment air partial pressure operating limits in TS Figure 3.6.4-1 with Figure 3.10-1 in this report.
- Reduce the containment temperature operating limit in TS 3.6.4 and TS 3.6.5 from 120 F to 115 F.
- Change the TS allowable values for SI RMT to $\leq$ 17.0% and $\geq$ 15.0% in TS 3.3.2.
- Replace the LOCTIC containment analysis methodology in NAPS UFSAR Chapter 6 with the GOTHIC analysis methodology from the NRC-approved topical report DOM-NAF-3.
- Change the LOCA AST licensing bases as documented in Sections 2.6 and 4.
- Revise the containment pressure limit from 0.5 psig during the time interval from 1 to 4 hours after the LOCA initiation to 2.0 psig during the time interval from 1 to 6 hours after the LOCA initiation.

The containment analyses were performed with the GOTHIC analytical methodology described in topical report DOM-NAF-3 [3], which was submitted to the NRC for generic review and approval on November 1, 2005 [4], supplemented in a letter dated July 14, 2006 [17], and approved by the NRC in a Safety Evaluation Report dated August 30, 2006 [27]. For North Anna Power Station, implementation of the GOTHIC methodology and analyses represents a change to a UFSAR evaluation methodology under 10 CFR 50.59 according to the screening performed in Attachment A. Because of the changes assumed in this report, the analyses and license changes must be submitted to the NRC for approval. The containment analysis margins for the proposed plant changes are summarized in Section 3.11. Adequate margin to the acceptance criteria is demonstrated.

With the changes described in Section 2, the LOCA AST analysis results in Table 4.10-1 show margin to the 10 CFR 50.67 limits for dose consequences. The AST analyses and revised technical bases must be submitted to the NRC for review and approval.

6.0 References

1. NRC Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors, September 13, 2004.

2. Letter from David A. Christian (Dominion) to NRC, "Dominion Energy Kewaunee, Inc., Dominion Nuclear Connecticut, Inc., Virginia Electric and Power Company, Kewaunee Power Station, Millstone Power Station Units 2 and 3, North Anna Power Station Units 1 and 2, Surry Power Station Units 1 and 2, Response to NRC Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," serial number 05-212, September 1, 2005.

3. Topical Report DOM-NAF-3, Revision 0, "GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment," October 2005.

4. Letter from Leslie N. Hartz (Dominion) to NRC, "Dominion Energy Kewaunee, Inc. (DEK), Dominion Nuclear Connecticut, Inc. (DNC), Virginia Electric and Power Company (Dominion), Kewaunee Power Station, Millstone Power Station Units 2 and 3, North Anna Power Station Units 1 and 2, Surry Power Station Units 1 and 2, Request for Approval of Topical Report DOM-NAF-3, GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment," serial number 05-745, November 1, 2005.

5. North Anna Power Station Updated Final Safety Analysis Report, Revision 41.

6. Technical Report NEI-04-07, Revision 0, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Volumes 1 and 2 (Safety Evaluation Report), December 2004.

7. North Anna Power Station Technical Specifications.

8. Letter from Gerald T. Bischof (Dominion) to NRC, "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Response to Request for Additional Information and Supplement to Proposed Technical Specification Change and Supporting Safety Analyses Revision to Address Generic Safety Issue 191," Serial No. 06-545, July 28, 2006.

9. WCAP-8264-P-A, Revision 1, "Westinghouse Mass and Energy Release Data for Containment Design," August 1975. (WCAP-8312-A is a Non-Proprietary version).

10. WCAP-10325-P-A, "Westinghouse LOCA Mass and Energy Release Model for Containment Design – March 1979 Version," May 1983. (WCAP-10326-A is a Non-Proprietary version.)

11. WCAP-11431, Revision 0, "Mass and Energy Releases Following a Steam Line Rupture for North Anna Units 1 and 2," February 1987.

12. WCAP-8822-P, "Mass and Energy Releases Following a Steam Line Rupture," September 1976, with Supplements 1 (WCAP-8822-S1-P-A) and 2 (WCAP-8822-S2-P-A) both dated September 1986. (WCAP-8860 is the Non-Proprietary version).

13. WCAP-7907-P-A, "LOFTRAN Code Description," April 1984.

14. Letter from W.L. Stewart (Virginia Power) to NRC, "Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Proposed Technical Specifications Change," Serial No. 87-385, March 2, 1988.

15. Letter from Leon B. Engle (NRC) to W. R. Cartwright (Virginia Power), "North Anna Units 1 and 2 – Issuance of Amendments Re: Containment Upper Limit Temperature (TAC Nos. 67535 and 67536)," December 14, 1988.

16. Letter from Leslie N. Hartz (Dominion) to USNRC, "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Proposed Technical Specification Change and Supporting Safety Analyses Revisions to Address Generic Safety Issue 191," Serial No. 06-014, January 31, 2006.

17. Letter from Gerald T. Bischof (Dominion) to NRC, "Dominion Energy Kewaunee, Inc. (DEK), Dominion Nuclear Connecticut, Inc. (DNC), Virginia Electric and Power Company (Dominion), Kewaunee Power Station, Millstone Power Station Units 2 and 3, North Anna Power Station Units 1 and 2, Surry Power Station Units 1 and 2, Supplement to Request for Approval of Topical Report DOM-NAF-3, GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment," Serial No. 06-544, July 14, 2006.

18. NRC IE Bulletin 79-01B, Environmental Qualification of Class 1E Equipment, January 14, 1980.

19. ISA-RP67.04.02-2000, "Methodologies for the Determination of Setpoints for Nuclear Safety Related Instrumentation."

20. Letter from Stephen Monarque (NRC) to David A. Christian (Dominion), "North Anna Power Station, Units 1 and 2 – Issuance of Amendments on Implementation of Alternate Source Term (TAC Nos. MC0776 and MC0777)," June 15, 2005.

21. "Iodine Removal From Containment Atmospheres by Boric Acid Spray," BNP-100, July 1970.

22. NUREG-CR-5966, "A Simplified Model of Aerosol Removal by Containment Sprays", D.A. Powers and S.B. Burson, Sandia National Laboratories, Albuquerque, New Mexico, 1993.

23. Regulatory Guide 1.183, "Alternate Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", July 2000.

24. Letter from Leslie N. Hartz (Dominion) to USNRC, "Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Proposed Technical Specification Changes Implementation of Alternate Source Term," Serial No. 03-464, September 12, 2003.

25. NUREG-0800, Standard Review Plan Section 6.5.2, Revision 1 (1981), page C-10 and Revision 2 (1988), page 6.5.2-10.

26. WCAP-14333-P-A, Revision 1, "Probabilistic Risk Analysis for the RPS and ESFAS Test Times and Completion Times," October 1998.

27. Letter from Ho K. Nieh (USNRC) to David A. Christian (Dominion), "Kewaunee Power Station (Kewaunee), Millstone Power Station, Unit Nos. 2 and 3 (Millstone 2 and 3), North Anna Power Station, Unit Nos. 1 and 2 (North Anna 1 and 2), and Surry Power Station, Unit Nos. 1 and 2 (Surry 1 and 2) – Approval of Dominion's Topical Report DOM-NAF-3, 'GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures Inside Containment'," August 30, 2006.

7.0 Regulatory Evaluation

7.1 No Significant Hazards Consideration

The proposed changes to the North Anna Technical Specifications (TS) and licensing basis support the resolution of NRC Generic Safety Issue 191 (GSI-191), Assessment of Debris Accumulation on PWR Sump Performance, and NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors. Seven changes are proposed as part of the requested amendment:

1) Replace the UFSAR evaluation methodology for analyzing the response to postulated pipe ruptures inside containment, including loss of coolant accident (LOCA) and main steam line break events, with the GOTHIC evaluation methodology in Dominion Topical Report DOM-NAF-3. The change to GOTHIC from the current LOCTIC code provides margins in LOCA peak containment pressure and other accident analysis results.

2) Increase the TS containment air partial pressure limits based on the GOTHIC containment analyses and LOCA Alternate Source Term (AST) analyses in Sections 3.0 and 4.0, respectively.

3) Reduce the TS maximum containment temperature limit from 120 F to 115 F.

4) Change the method of starting the recirculation spray (RS) pumps from timers, after a containment depressurization actuation on High High containment pressure, to refueling water storage tank (RWST) Level Low coincident with High High containment pressure. This change ensures adequate water level to submerge the containment sump strainer and meets all safety analysis acceptance criteria. The proposed amendment modifies the North Anna Technical Specifications surveillance requirements to verify that each RS pump automatically starts on a CDA test signal after receipt of an RWST Level Low coincident with High High containment pressure. A plant modification associated with the proposed change to the Technical Specifications is required to install the new RS pump start circuitry.

5) Change the LOCA AST analysis basis to demonstrate acceptable dose consequences for the increased containment air partial pressure limits and the modification to RS pump start.

6) Change the TS allowable values for the safety injection (SI) automatic recirculation mode transfer (RMT) signal to be consistent with a plant setpoint change that is included in the GOTHIC containment analyses.

7) Modify the surveillance requirements for the sump to reflect the new containment sump strainer design.

Dominion has reviewed the requirements of 10 CFR 50.92 as they relate to the proposed changes to the North Anna Power Station Units 1 and 2 Technical Specifications and licensing basis and has determined that a significant hazards consideration does not exist. The basis for this determination is as follows:

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

   No.

   The proposed changes include a physical alteration to the RS system to start the inside and outside RS pumps on RWST Level Low coincident with High High containment pressure. The RS system is used for accident mitigation only, and changes in the operation of the RS system cannot have an impact on the probability of an accident. The other changes do not affect equipment and are not accident initiators. The RWST Level Low instrumentation will comply with all applicable regulatory requirements and design criteria (e.g., train separation, redundancy, and single failure). Therefore, the design functions performed by the RS system are not changed.

   Delaying the start of the RS pumps creates more challenging long-term containment pressure and temperature profiles. The environmental qualification of safety-related equipment inside containment was confirmed to be acceptable, and accident mitigation systems will continue to operate within design temperatures and pressures. Delaying the RS pump start reduces the emergency diesel generator loading early during a design basis accident, and staggering the RS pump start avoids overloading on each emergency bus. The reduction in iodine removal efficiency during the delay period is offset by changes to other assumptions in the LOCA dose analysis. The predicted offsite doses and control room doses following a design basis LOCA remain within regulatory limits.

   The UFSAR safety analysis acceptance criteria continue to be met for the proposed changes to the RS pump start method, the proposed TS containment air partial pressure limits, the proposed TS containment temperature limit, the implementation of the GOTHIC containment analysis methodology, the proposed change to the SI RMT allowable values, and the changes to the LOCA dose consequences analyses. Based on this discussion, the proposed amendments do not increase the probability or consequence of an accident previously evaluated.

2. Does the proposed license amendment create the possibility of a new or different kind of accident from any accident previously identified?

   No.

The proposed change alters the RS pump circuitry by initiating the start sequence with a new RWST Level Low signal instead of a timer after the High High containment pressure setpoint is reached. The timers for the inside RS pumps will be used to sequence pump starts and preclude diesel generator overloading. The RS pump function is not changed. The RWST Level Low instrumentation will be included as part of the Engineered Safety Features Actuation System (ESFAS) instrumentation in the North Anna TS and will be subject to the ESFAS surveillance requirements. The design of the RWST Level Low instrumentation complies with all applicable regulatory requirements and design criteria. The failure modes have been analyzed to ensure that the RWST Level Low circuitry can withstand a single active failure without affecting the RS system design functions. The RS system is an accident mitigation system only, so no new accident initiators are created.

The remaining changes to the containment analysis methodology, the containment air partial pressures, the maximum containment temperature operating limit, the TS allowable values for SI RMT, and the LOCA AST analysis basis do not impact plant equipment design or function. Together, the changes assure that there is adequate margin available to meet the safety analysis criteria and that dose consequences are within regulatory limits. The proposed changes do not introduce failure modes, accident initiators, or malfunctions that would cause a new or different kind of accident. Therefore, the proposed changes do not create the possibility of a new or different kind of accident from any accident previously identified.

3. <u>Does the proposed license amendment involve a significant reduction in a margin of safety?</u>

No.

The changes to the actuation of the RS pumps and the increased containment air partial pressure have created an adverse effect on the containment response analyses and the LOCA dose analysis. Analyses have been performed that show the containment design basis limits are satisfied and the post-LOCA offsite and control room doses meet the required criteria for the proposed changes to the containment analysis methodology, the RS pump start method, the TS containment air partial pressure limits, the TS containment temperature maximum limit, the TS allowable values for SI RMT, and the LOCA AST bases. Therefore, the proposed amendment does not involve a significant reduction in a margin of safety.

7.2 Regulatory Requirements

The regulatory requirements and standards applicable to the requested change are the following:

- 10 CFR 50.49, Environmental Qualification Of Electrical Equipment Important To Safety For Nuclear Power Plants

- 10 CFR 50.67, Alternate Source Term

Sections 3.0 and 4.0 conclude that the proposed change will continue to comply with these regulatory requirements.

The GDC included in Appendix A to 10 CFR Part 50 did not become effective until May 21, 1971. The Construction Permits for North Anna Units 1 and 2 were issued prior to May 21, 1971; consequently, these units were not subject to GDC requirements. [Reference SECY-92-223 dated September 18, 1992] However, the plant was designed to meet the intent of the draft GDC.

- *Criterion 38--Containment heat removal.* "A system to remove heat from the reactor containment shall be provided. The system safety function shall be to reduce rapidly, consistent with the functioning of other associated systems, the containment pressure and temperature following any loss-of-coolant accident and maintain them at acceptably low levels."

  There are no changes to the Recirculation Spray system or containment sump design that impact this general design criterion. Section 3.0 concludes that the proposed change will continue to comply with this regulatory requirement.

- *Criterion 41--Containment atmosphere cleanup.* "Systems to control fission products, hydrogen, oxygen, and other substances which may be released into the reactor containment shall be provided as necessary to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents, and to control the concentration of hydrogen or oxygen and other substances in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

  Each system shall have suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) its safety function can be accomplished, assuming a single failure."

There are no changes to the Quench Spray and Recirculation Spray systems or containment sump design that impact this general design criterion. Section 3.0 concludes that the proposed change will continue to comply with this regulatory requirement.

- *Criterion 50--Containment design basis.* "The reactor containment structure, including access openings, penetrations, and the containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident. This margin shall reflect consideration of (1) the effects of potential energy sources which have not been included in the determination of the peak conditions, such as energy in steam generators and as required by §50.44 energy from metal-water and other chemical reactions that may result from degradation but not total failure of emergency core cooling functioning, (2) the limited experience and experimental data available for defining accident phenomena and containment responses, and (3) the conservatism of the calculational model and input parameters."

  There are no changes to the Quench Spray and Recirculation Spray systems or containment design that impact this general design criterion. Section 3.0 concludes that the proposed change will continue to comply with this regulatory requirement.

- *IEEE-279 Standard, Nuclear Power Plant Protection Systems,* August 1968.

  The changes to the Recirculation Spray system actuation circuitry design meet this design standard. Section 2.0 concludes that the proposed change will continue to comply with design standard.

There are no changes to the Containment System or Quench and Recirculation Spray systems design or operation or the containment analysis method such that compliance with any of the above regulatory requirements and standards would come into question. The analysis completed to support the changes ensures the containment will continue to meet the applicable regulatory requirements. The plant will continue to comply with all applicable regulatory requirements.

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

8.0 Environmental Assessment

The proposed change meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9) as follows:

(i) The amendment involves no significant hazards consideration.

As described above, the proposed TS change does not involve a significant hazards consideration.

(ii) There is no significant change in the types or significant increase in the amounts of any effluents that may be released offsite.

Delaying the start of the RS pumps creates more challenging long-term containment pressure and temperature profiles. However, the accident mitigation systems will continue to operate within design temperatures and pressures. The reduction in iodine removal efficiency during the delay period is offset by changes to other assumptions in the LOCA dose analysis and the dose consequences are within regulatory limits. The change to the TS allowable values for SI RMT has been included in the containment analyses that show margin to the design limits. The remaining changes to the containment analysis methodology, the containment air partial pressures, the containment temperature limit, and the LOCA AST analysis basis do not impact plant equipment design or function. Therefore, there is no significant change in the types or amount of any effluents that may be released offsite.

(iii) There is no significant increase in individual or cumulative occupational radiation exposure.

Delaying the start of the RS pumps creates more challenging long-term containment pressure and temperature profiles. However, the accident mitigation systems will continue to operate within design temperatures and pressures. The reduction in iodine removal efficiency during the delay period is offset by changes to other assumptions in the LOCA dose analysis so that the dose consequences are within regulatory limits. The change to the TS allowable values for SI RMT has been included in the containment analyses that show margin to the design limits. The remaining changes to the containment analysis methodology, the containment air partial pressures, and the LOCA AST analysis basis do not impact plant equipment design or function. Therefore, there is no significant change in the individual or cumulative occupational radiation exposure.

Based on the above assessment, Dominion concludes that the proposed change meets the criteria specified in 10 CFR 51.22 for a categorical exclusion from the requirements of 10 CFR 51.22 relative to requiring a specific environmental assessment or impact statement by the Commission.

The proposed changes—the change to GOTHIC from the current LOCTIC code, the increase in the TS containment air partial pressure limits, the change to the method of starting the RS pumps from timers to the RWST level, the changes to the LOCA AST analysis basis, the change to the maximum operating containment temperature, and the change to the TS allowable values for SI RMT—provide additional margin to support the resolution of NRC GSI-191 and NRC Generic Letter 2004-02. The proposed changes have no adverse safety impact and do not significantly affect radiological dose consequences to the public or to plant workers.

ATTACHMENT 2

PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

MARKED-UP TECHNICAL SPECIFICATION PAGES

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2

Table 3.3.2-1 (page 2 of 4)
Engineered Safety Feature Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
2. Containment Spray Systems					
a. Manual Initiation	1, 2, 3, 4	2 per train, 2 trains	B	SR 3.3.2.7	NA
b. Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
c. Containment Pressure					
High High	1, 2, 3	4	E	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≤ 28.45 psia
INSERT 1 →					
3. Containment Isolation					
a. Phase A Isolation					
(1) Manual Initiation	1, 2, 3, 4	2	B	SR 3.3.2.7	NA
(2) Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
(3) Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
b. Phase B Isolation					
(1) Manual Initiation	Refer to Function 2.a (Containment Spray–Manual Initiation) for all functions and requirements.				
(2) Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
(3) Containment Pressure					
High High	Refer to Function 2.c (Containment Spray–Containment Pressure High High) for all functions and requirements.				

Table 3.3.2-1 (page 4 of 4)
Engineered Safety Feature Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
6. Auxiliary Feedwater					
a. Automatic Actuation Logic and Actuation Relays	1, 2, 3	2 trains	G	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
b. SG Water Level–Low Low	1, 2, 3	3 per SG	D	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ 17%
c. Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
d. Loss of Offsite Power	1, 2, 3	1 per bus, 2 buses	F	SR 3.3.2.6 SR 3.3.2.8 SR 3.3.2.9	≥ 2184 V
e. Trip of all Main Feedwater Pumps	1, 2	2 per pump	H	SR 3.3.2.7 SR 3.3.2.9	NA
7. Automatic Switchover to Containment Sump					
a. Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
b. Refueling Water Storage Tank (RWST) Level–Low Low	1, 2, 3, 4	4	I	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ ~~16.4%~~ 15% and ≤ ~~20.4%~~ 17%
Coincident with Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
8. ESFAS Interlocks					
a. Reactor Trip, P-4	1, 2, 3	1 per train, 2 trains	F	SR 3.3.2.7	NA
b. Pressurizer Pressure, P-11	1, 2, 3	3	J	SR 3.3.2.1 SR 3.3.2.8	≤ 2010 psig
c. T_{avg}–Low Low, P-12	1, 2, 3	1 per loop	J	SR 3.3.2.1 SR 3.3.2.8	≥ 542°F and ≤ 545°F

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.5.2.5	Verify each ECCS automatic valve in the flow path that is not locked, sealed, or otherwise secured in position, actuates to the correct position on an actual or simulated actuation signal.	18 months
SR 3.5.2.6	Verify each ECCS pump capable of starting automatically starts automatically on an actual or simulated actuation signal.	18 months
SR 3.5.2.7	Verify each ECCS throttle valve listed below is secured in the correct position. Unit 1 Valve Number / Unit 2 Valve Number 1-SI-188 / 2-SI-89 1-SI-191 / 2-SI-97 1-SI-193 / 2-SI-103 1-SI-203 / 2-SI-116 1-SI-204 / 2-SI-111 1-SI-205 / 2-SI-123 component	18 months
SR 3.5.2.8	Verify, by visual inspection, each ECCS train containment sump ~~suction inlet~~ is not restricted by debris and ~~the suction inlet trash racks and screens~~ show s no evidence of structural distress or abnormal corrosion.	18 months

REPLACE WITH NEW Figure 3.6.4-1 INSERT A

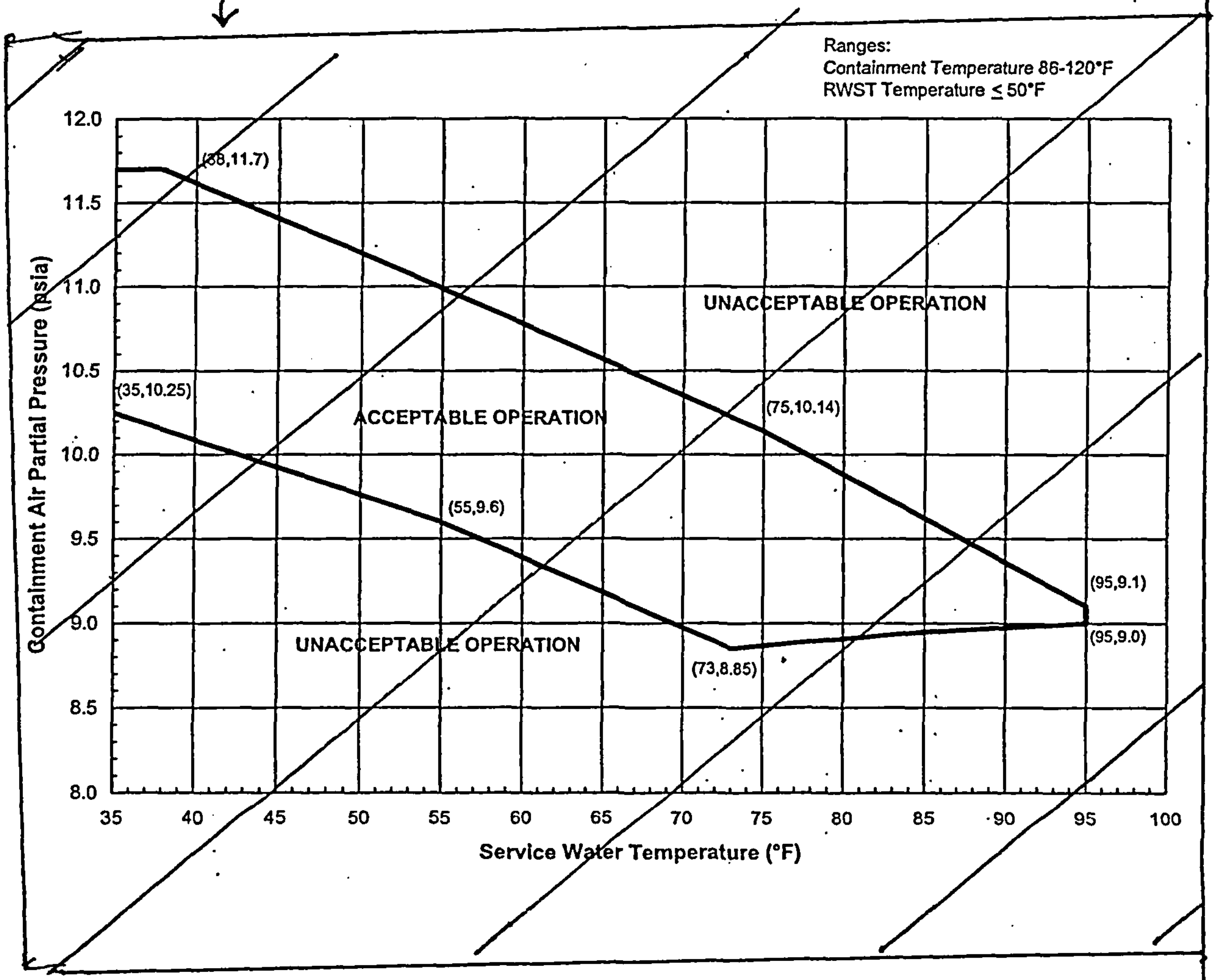


Figure 3.6.4-1 (page 1 of 1)
Containment Air Partial Pressure Versus
Service Water Temperature

3.6 CONTAINMENT SYSTEMS

3.6.5 Containment Air Temperature

LCO 3.6.5 Containment average air temperature shall be ≥ 86°F and ≤ ~~120~~°F.
115°

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Containment average air temperature not within limits.	A.1 Restore containment average air temperature to within limits.	8 hours
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3.	6 hours
	AND	
	B.2 Be in MODE 5.	36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.6.5.1 Verify containment average air temperature is within limits.	24 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.7.6	Verify on an actual or simulated actuation signal(s): a. Each RS automatic valve in the flow path that is not locked, sealed, or otherwise secured in position, actuates to the correct position; b. Each RS pump starts automatically; and c. Each casing cooling pump starts automatically.	18 months
SR 3.6.7.~~7~~8	Verify each spray nozzle is unobstructed.	Following maintenance which could cause nozzle blockage
SR 3.6.7.7	Verify, by visual inspection, each RS train containment sump component is not restricted by debris and shows no evidence of structural distress or abnormal corrosion	18 months

5.5 Programs and Manuals

5.5.14 Safety Function Determination Program (SFDP) (continued)

analysis cannot be performed. For the purpose of this program, a loss of safety function may exist when a support system is inoperable, and:

a. A required system redundant to the system(s) supported by the inoperable support system is also inoperable; or

b. A required system redundant to the system(s) in turn supported by the inoperable supported system is also inoperable; or

c. A required system redundant to the support system(s) for the supported systems (a) and (b) above is also inoperable.

The SFDP identifies where a loss of safety function exists. If a loss of safety function is determined to exist by this program, the appropriate Conditions and Required Actions of the LCO in which the loss of safety function exists are required to be entered. When a loss of safety function is caused by the inoperability of a single Technical Specification support system, the appropriate Conditions and Required Actions to enter are those of the support system.

5.5.15 Containment Leakage Rate Testing Program

a. A program shall establish the leakage rate testing of the containment as required by 10 CFR 50.54(o) and 10 CFR 50, Appendix J, Option B, as modified by approved exemptions. This program shall be in accordance with the guidelines contained in Regulatory Guide 1.163, "Performance-Based Containment Leak-Test Program," dated September 1995 as modified by the following exception:

NEI 94-01-1995, Section 9.2.3: The first Unit 1 Type A test performed after the April 3, 1993 Type A test shall be performed no later than April 2, 2008.

b. The calculated peak containment internal pressure for the design basis loss of coolant accident, P_a, is ~~44.1~~ 42.7 psig. The containment design pressure is 45 psig.

c. The maximum allowable containment leakage rate, L_a, at P_a, shall be 0.1% of containment air weight per day.

(continued)

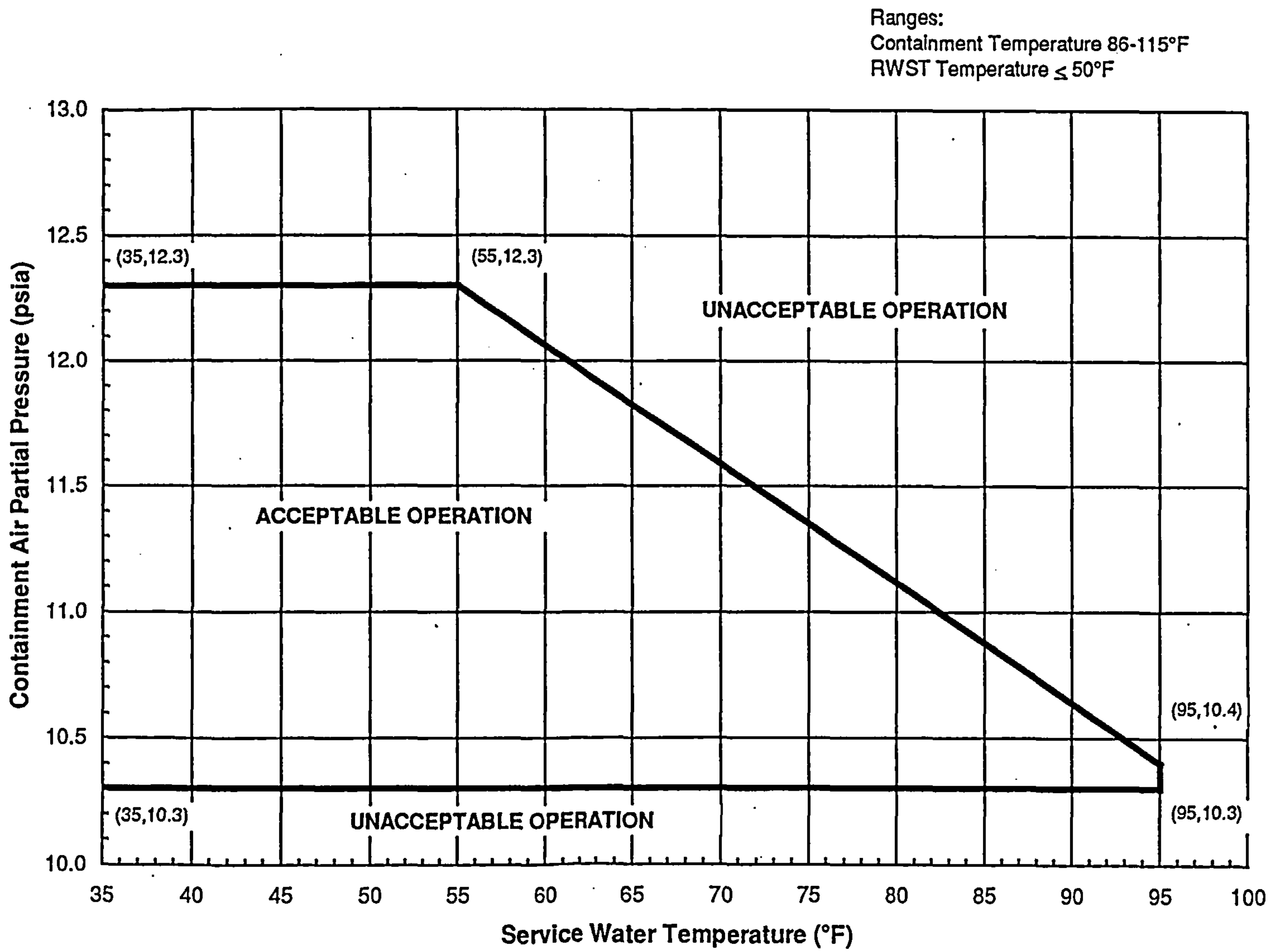
TS Inserts 1 and A

Insert #1: TS 3.3.2, Table 3.3.2-1

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
d. Refueling Water Storage Tank (RWST) Level - Low	1, 2, 3	3	D	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ 59% and ≤ 61%
Coincident with Containment Pressure-High High	Refer to Function 2.c (Containment Spray-Containment Pressure-High High) for all functions and requirements.				

INSERT A for TS 3.6.4: Replace Figure 3.6.4-1 with the below figure

Figure 3.6.4-1: Containment Air Partial Pressure Versus Service Water Temperature



ATTACHMENT 3

PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

PROPOSED TECHNICAL SPECIFICATION PAGES

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2

Table 3.3.2-1 (page 2 of 4)
Engineered Safety Feature Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
2. Containment Spray Systems					
a. Manual Initiation	1, 2, 3, 4	2 per train, 2 trains	B	SR 3.3.2.7	NA
b. Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
c. Containment Pressure					
High High	1, 2, 3	4	E	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≤ 28.45 psia
d. Refueling Water Storage Tank (RWST) Level-Low	1, 2, 3	3	D	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ 59% and ≤ 61%
Coincident with Containment Pressure—High High	Refer to Function 2.c (Containment Spray-Containment Pressure—High High) for all functions and requirements.				
3. Containment Isolation					
a. Phase A Isolation					
(1) Manual Initiation	1, 2, 3, 4	2	B	SR 3.3.2.7	NA
(2) Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
(3) Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
b. Phase B Isolation					
(1) Manual Initiation	Refer to Function 2.a (Containment Spray—Manual Initiation) for all functions and requirements.				
(2) Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
(3) Containment Pressure					
High High	Refer to Function 2.c (Containment Spray—Containment Pressure High High) for all functions and requirements.				

Table 3.3.2-1 (page 4 of 4)
Engineered Safety Feature Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
6. Auxiliary Feedwater					
a. Automatic Actuation Logic and Actuation Relays	1, 2, 3	2 trains	G	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
b. SG Water Level—Low Low	1, 2, 3	3 per SG	D	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ 17%
c. Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
d. Loss of Offsite Power	1, 2, 3	1 per bus, 2 buses	F	SR 3.3.2.6 SR 3.3.2.8 SR 3.3.2.9	≥ 2184 V
e. Trip of all Main Feedwater Pumps	1, 2	2 per pump	H	SR 3.3.2.7 SR 3.3.2.9	NA
7. Automatic Switchover to Containment Sump					
a. Automatic Actuation Logic and Actuation Relays	1, 2, 3, 4	2 trains	C	SR 3.3.2.2 SR 3.3.2.3 SR 3.3.2.5	NA
b. RWST Level—Low Low	1, 2, 3, 4	4	I	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.8 SR 3.3.2.9	≥ 15% and ≤ 17%
Coincident with Safety Injection	Refer to Function 1 (Safety Injection) for all initiation functions and requirements.				
8. ESFAS Interlocks					
a. Reactor Trip, P-4	1, 2, 3	1 per train, 2 trains	F	SR 3.3.2.7	NA
b. Pressurizer Pressure, P-11	1, 2, 3	3	J	SR 3.3.2.1 SR 3.3.2.8	≤ 2010 psig
c. T_{avg}—Low Low, P-12	1, 2, 3	1 per loop	J	SR 3.3.2.1 SR 3.3.2.8	≥ 542°F and ≤ 545°F

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.5.2.5	Verify each ECCS automatic valve in the flow path that is not locked, sealed, or otherwise secured in position, actuates to the correct position on an actual or simulated actuation signal.	18 months
SR 3.5.2.6	Verify each ECCS pump capable of starting automatically starts automatically on an actual or simulated actuation signal.	18 months
SR 3.5.2.7	Verify each ECCS throttle valve listed below is secured in the correct position. Unit 1 Valve Number / Unit 2 Valve Number 1-SI-188 / 2-SI-89 1-SI-191 / 2-SI-97 1-SI-193 / 2-SI-103 1-SI-203 / 2-SI-116 1-SI-204 / 2-SI-111 1-SI-205 / 2-SI-123	18 months
SR 3.5.2.8	Verify, by visual inspection, each ECCS train containment sump component is not restricted by debris and shows no evidence of structural distress or abnormal corrosion.	18 months

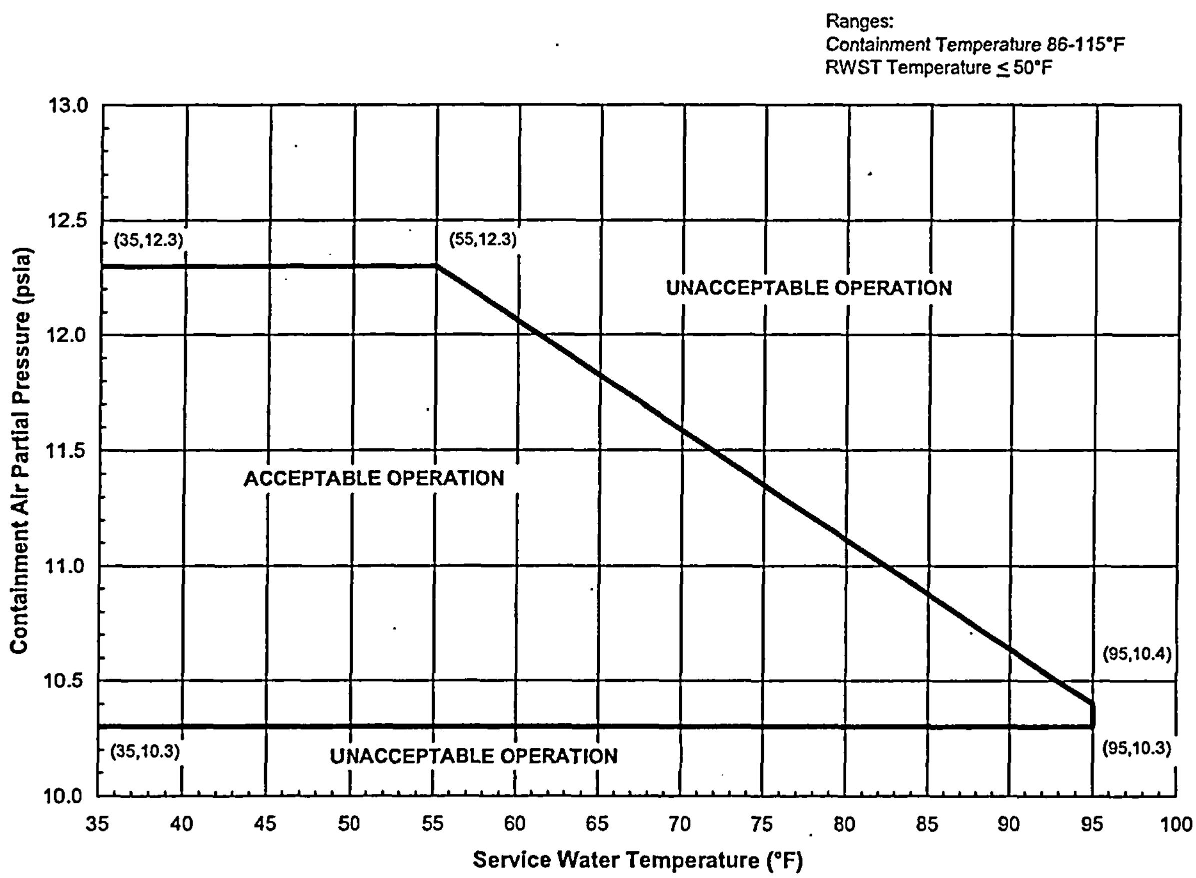


Figure 3.6.4-1 (page 1 of 1)
Containment Air Partial Pressure Versus
Service Water Temperature

3.6 CONTAINMENT SYSTEMS

3.6.5 Containment Air Temperature

LCO 3.6.5 Containment average air temperature shall be ≥ 86°F and ≤ 115°F.

APPLICABILITY: MODES 1, 2, 3, and 4.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Containment average air temperature not within limits.	A.1 Restore containment average air temperature to within limits.	8 hours
B. Required Action and associated Completion Time not met.	B.1 Be in MODE 3. AND B.2 Be in MODE 5.	6 hours 36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.6.5.1 Verify containment average air temperature is within limits.	24 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.7.6	Verify on an actual or simulated actuation signal(s): a. Each RS automatic valve in the flow path that is not locked, sealed, or otherwise secured in position, actuates to the correct position; b. Each RS pump starts automatically; and c. Each casing cooling pump starts automatically.	18 months
SR 3.6.7.7	Verify, by visual inspection, each RS train containment sump component is not restricted by debris and shows no evidence of structural distress or abnormal corrosion.	18 months
SR 3.6.7.8	Verify each spray nozzle is unobstructed.	Following maintenance which could cause nozzle blockage

5.5 Programs and Manuals

5.5.14 Safety Function Determination Program (SFDP) (continued)

analysis cannot be performed. For the purpose of this program, a loss of safety function may exist when a support system is inoperable, and:

a. A required system redundant to the system(s) supported by the inoperable support system is also inoperable; or

b. A required system redundant to the system(s) in turn supported by the inoperable supported system is also inoperable; or

c. A required system redundant to the support system(s) for the supported systems (a) and (b) above is also inoperable.

The SFDP identifies where a loss of safety function exists. If a loss of safety function is determined to exist by this program, the appropriate Conditions and Required Actions of the LCO in which the loss of safety function exists are required to be entered. When a loss of safety function is caused by the inoperability of a single Technical Specification support system, the appropriate Conditions and Required Actions to enter are those of the support system.

5.5.15 Containment Leakage Rate Testing Program

a. A program shall establish the leakage rate testing of the containment as required by 10 CFR 50.54(o) and 10 CFR 50, Appendix J, Option B, as modified by approved exemptions. This program shall be in accordance with the guidelines contained in Regulatory Guide 1.163, "Performance-Based Containment Leak-Test Program," dated September 1995 as modified by the following exception:

   NEI 94-01-1995, Section 9.2.3: The first Unit 1 Type A test performed after the April 3, 1993 Type A test shall be performed no later than April 2, 2008.

b. The calculated peak containment internal pressure for the design basis loss of coolant accident, P_a, is 42.7 psig. The containment design pressure is 45 psig.

c. The maximum allowable containment leakage rate, L_a, at P_a, shall be 0.1% of containment air weight per day.

(continued)

Serial No. 06-849
Docket Nos. 50-338/339

ATTACHMENT 4

PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

MARKED-UP TECHNICAL SPECIFICATION BASES PAGES

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2

TS Bases Inserts 2 through 14

Insert #2: Page B 3.3.2-14

When the RWST level reaches the low setpoint coincident with Containment Pressure-High High, the RS pumps receive a start signal. The outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. Water is drawn from the containment sump through heat exchangers and discharged to the RS nozzle headers.

Insert #3: Page B 3.3.2-14

RS is actuated manually or by RWST Level-Low coincident with Containment Pressure-High High.

Insert #4: Page B 3.3.2-16

d. <u>RWST Level-Low Coincident with Containment Pressure-High High</u>

This signal starts the RS system to provide protection against a LOCA inside containment. The Containment Pressure-High High (ESFAS Function 2.c) signal aligns the RS system for spray flow delivery (e.g., opens isolation valves) but does not start the RS pumps. The RWST Level-Low coincident with Containment Pressure-High High provides the automatic start signal for the inside RS and outside RS pumps. Once the coincidence trip is satisfied, the outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. The delay time is sufficient to avoid simultaneous starting of the RS pumps on the same emergency diesel generator. This ESFAS function ensures that adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements following a LOCA. The RS system is not required for SLB mitigation.

Automatic initiation of RS must be OPERABLE in MODES 1, 2, and 3 when there is a potential for an accident to occur, and sufficient energy exists in the primary and secondary systems to pose a threat to containment integrity due to overpressure conditions. The requirement for automatic initiation of RWST Level-Low to be operable in MODES 1, 2, and 3 is consistent with the operability requirements for Containment Pressure-High High. Manual initiation of the RS system is required in MODE 4, even though automatic initiation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA. In MODES 5 and 6, there is insufficient energy in the primary and secondary systems to result in containment overpressure. In MODES 5 and 6, there is also adequate time for the operators to evaluate unit conditions and respond to mitigate the consequences of abnormal conditions by manually starting individual components. An operator can initiate RS at any time from the control room by using the pump control switch. The manual function would be used only when adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements.

Insert #5: Pages B 3.6.4-1, B 3.6.6-1, B 3.6.6-2, B 3.6.7-1, B 3.6.7-2, B 3.6.7-3

to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours

Insert #6: Page B 3.6.4-1

Controlling containment air partial pressure limits within prescribed limits ensures adequate net positive suction head (NPSH) for the recirculation spray and low head safety injection pumps following a DBA.

Insert #7: Page B 3.6.4-2

Controlling containment air partial pressure limits within prescribed limits ensures adequate NPSH for the recirculation spray and low head safety injection pumps following a DBA. The minimum containment air partial pressure is an initial condition for the NPSH analyses.

Insert #8: Page B 3.6.4-3

the containment structure will depressurize to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a DBA.

Insert #9: Page B 3.6.7-2

Refueling water storage tank (RWST) Level-Low coincident with Containment Pressure-High High provides the automatic start signal for the inside RS and outside RS pumps. Once the coincidence logic is satisfied, the outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. The delay time is sufficient to avoid simultaneous starting of the RS pumps on the same emergency diesel generator. The coincident trip ensures that adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements following a loss of coolant accident (LOCA). The RS system is not required for steam line break (SLB) mitigation.

Insert #10: Page B 3.6.7-8

The RS pumps are verified to start with an actual or simulated RWST Level-Low signal coincident with a Containment Pressure-High High signal. The start delay times for the inside RS pumps are also verified.

Insert #11: Pages B 3.6.5-2 and B 3.6.7-3

The postulated SLB events are analyzed without credit for the RS system.

Insert #12: Page B 3.6.7-4

The RS System actuation model from the containment analysis is based upon a response associated with exceeding the Containment Pressure-High High signal setpoint and RWST level decreasing below the RWST Level-Low setpoint. The containment analysis models account conservatively for instrument uncertainty for the Containment Pressure-High High setpoint and the RWST Level-Low setpoint. The RS System's total response time is determined by the time to satisfy the coincidence logic, the timer delay for the inside RS pumps, pump startup time, and piping fill time.

Insert #13: Page B 3.6.7-8

SR 3.6.7.7

Periodic inspections of the containment sump components ensure that they are unrestricted and stay in proper operating condition. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and on the need to have access to the location. This Frequency has been found to be sufficient to detect abnormal degradation and is confirmed by operating experience.

Insert #14: Page B 3.6.4-2

The SLB analysis resulted in a maximum peak containment internal pressure of 43.0 psig, which is less than the maximum design internal pressure for the containment.

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

1. Safety Injection (continued)

~~f.~~ g. Safety Injection–High Steam Flow in Two Steam Lines Coincident With T_{avg}–Low Low or Coincident With Steam Line Pressure–Low (continued)

With the transmitters located inside the containment (T_{avg}) or near the steam lines (High Steam Flow), it is possible for them to experience adverse steady state environmental conditions during an SLB event. The trip setpoint reflects only steady state instrument uncertainties.

This Function must be OPERABLE in MODES 1, 2, and 3 (above P-12) when a secondary side break or stuck open valve could result in the rapid depressurization of the steam line(s). This signal may be manually blocked by the operator when below the P-12 setpoint. Above P-12, this Function is automatically unblocked. This Function is not required OPERABLE below P-12 because the reactor is not critical, so steam line break is not a concern. SLB may be addressed by Containment Pressure High (inside containment) or by High Steam Flow in Two Steam Lines coincident with Steam Line Pressure–Low, for Steam Line Isolation, followed by High Differential Pressure Between Two Steam Lines, for SI. This Function is not required to be OPERABLE in MODE 4, 5, or 6 because there is insufficient energy in the secondary side of the unit to cause an accident.

2. Containment Spray Systems

The Containment Spray Systems (Quench Spray (QS) and Recirculation Spray (RS)) provide ~~s~~ ~~three~~ four primary functions:

1. Lowers containment pressure and temperature after an HELB in containment;
2. Reduces the amount of radioactive iodine in the containment atmosphere; ~~and~~
3. Adjusts the pH of the water in the containment sump after a large break LOCA; and
4. Remove heat from Containment.

BASES

Systems

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray (continued)

These functions are necessary to:

- Ensure the pressure boundary integrity of the containment structure;
- Limit the release of radioactive iodine to the environment in the event of a failure of the containment structure; and
- Minimize corrosion of the components and systems inside containment following a LOCA.

The containment spray actuation signal starts the ~~quench spray~~ QS pumps and aligns the discharge of the pumps to the containment spray nozzle headers in the upper levels of containment. ~~Water is initially drawn from the RWST by the quench spray pumps and mixed with a sodium hydroxide solution from the chemical addition tank.~~ INSERT 2 When the RWST reaches the low low level setpoint, the Low Head Safety Injection pump suctions are shifted to the containment sump. Containment spray is actuated manually or by Containment Pressure—High High signal. INSERT 3

a. Containment Spray—Manual Initiation

The operator can initiate containment spray at any time from the control room by simultaneously turning two containment spray actuation switches in the same train. Because an inadvertent actuation of containment spray could have such serious consequences, two switches must be turned simultaneously to initiate containment spray. There are two sets of two switches each in the control room.

Simultaneously turning the two switches in either set will actuate containment spray in both trains in the same manner as the automatic actuation signal. Two Manual Initiation switches in each train are required to be OPERABLE to ensure no single failure disables the Manual Initiation Function. Note that Manual Initiation of containment spray also actuates Phase B containment isolation.

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

b. Containment Spray-Automatic Actuation Logic and Actuation Relays

Automatic actuation logic and actuation relays consist of the same features and operate in the same manner as described for ESFAS Function 1.b.

Manual and automatic initiation of containment spray must be OPERABLE in MODES 1, 2, and 3 when there is a potential for an accident to occur, and sufficient energy exists in the primary or secondary systems to pose a threat to containment integrity due to overpressure conditions. Manual initiation is also required in MODE 4, even though automatic actuation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA. However, because of the large number of components actuated on a containment spray, actuation is simplified by the use of the manual actuation switches. Automatic actuation logic and actuation relays must be OPERABLE in MODE 4 to support system manual initiation. In MODES 5 and 6, there is insufficient energy in the primary and secondary systems to result in containment overpressure. In MODES 5 and 6, there is also adequate time for the operators to evaluate unit conditions and respond, to mitigate the consequences of abnormal conditions by manually starting individual components.

c. Containment Spray-Containment Pressure

This signal provides protection against a LOCA or an SLB inside containment. The transmitters (d/p cells) are located outside of containment with the sensing line (high pressure side of the transmitter) located inside containment. The transmitters and electronics are located outside of containment. Thus, they will not experience any adverse environmental conditions and the Allowable Value reflects only steady state instrument uncertainties.

This is one of few Functions that requires the bistable output to energize to perform its required action. It is not desirable to have a loss of power

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

c. Containment Spray–Containment Pressure (continued)

actuate containment spray, since the consequences of an inadvertent actuation of containment spray could be serious. Note that this Function also has the inoperable channel placed in bypass rather than trip to decrease the probability of an inadvertent actuation.

North Anna uses four channels in a two-out-of-four logic configuration and the Containment Pressure–High High Setpoint Actuates Containment Spray Systems. Since containment pressure is not used for control, this arrangement exceeds the minimum redundancy requirements. Additional redundancy is warranted because this Function is energize to trip. Containment Pressure–High High must be OPERABLE in MODES 1, 2, and 3 when there is sufficient energy in the primary and secondary sides to pressurize the containment following a pipe break. In MODES 4, 5, and 6, there is insufficient energy in the primary and secondary sides to pressurize the containment and reach the Containment Pressure–High High setpoints.

INSERT 4

3. Containment Isolation

Containment Isolation provides isolation of the containment atmosphere, and all process systems that penetrate containment, from the environment. This Function is necessary to prevent or limit the release of radioactivity to the environment in the event of a large break LOCA.

There are two separate Containment Isolation signals, Phase A and Phase B. Phase A isolation isolates all automatically isolable process lines, except component cooling water (CC) and instrument air (IA), at a relatively low containment pressure indicative of primary or secondary system leaks. A list of the process lines is provided in the Technical Requirements Manual (Ref. 9). For these types of events, forced circulation cooling using the reactor coolant pumps (RCPs) and SGs is the preferred (but not required) method of decay heat removal. Since CC is required to support RCP operation, not isolating CC on the low pressure Phase A signal

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

3. Containment Isolation (continued)

a. Containment Isolation–Phase A Isolation (continued)

conditions and manually actuate individual isolation valves in response to abnormal or accident conditions.

(3) Phase A Isolation–Safety Injection

Phase A Containment Isolation is also initiated by all Functions that initiate SI. The Phase A Containment Isolation requirements for these Functions are the same as the requirements for their SI function. Therefore, the requirements are not repeated in Table 3.3.2-1. Instead, Function 1, SI, is referenced for all initiating Functions and requirements.

b. Containment Isolation–Phase B Isolation

Systems

Phase B Containment Isolation is accomplished by Manual Initiation, Automatic Actuation Logic and Actuation Relays, and by Containment Pressure channels (the same channels that actuate Containment Spray, Function 2). The Containment Pressure trip of Phase B Containment Isolation is energized to trip in order to minimize the potential of spurious trips that may damage the RCPs.

(1) Phase B Isolation–Manual Initiation

(2) Phase B Isolation–Automatic Actuation Logic and Actuation Relays

Manual and automatic initiation of Phase B containment isolation must be OPERABLE in MODES 1, 2, and 3, when there is a potential for an accident to occur. Manual initiation is also required in MODE 4 even though automatic actuation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA. However, because of the large number of components actuated on a Phase B containment isolation, actuation is simplified by the use of the Containment Spray manual actuation switches.

(continued)

BASES

ACTIONS

C.1, C.2.1, and C.2.2 (continued)

experience, to reach the required unit conditions from full power conditions in an orderly manner and without challenging unit systems.

The Required Actions are modified by a Note that allows one train to be bypassed for up to 4 hours for surveillance testing, provided the other train is OPERABLE. This allowance is based on the reliability analysis assumption of Reference 8 that 4 hours is the average time required to perform channel surveillance.

D.1, D.2.1, and D.2.2

Condition D applies to:

- Containment Pressure–High;
- Pressurizer Pressure–Low Low;
- Steam Line Differential Pressure–High;
- High Steam Flow in Two Steam Lines Coincident With T_{avg}–Low Low or Coincident With Steam Line Pressure–Low;
- Containment Pressure–Intermediate High High;
- SG Water level–Low Low; ~~and~~
- SG Water level–High High (P-14); and
- RWST Level-Low Coincident with Containment Pressure-High High

If one channel is inoperable, 72 hours are allowed to restore the channel to OPERABLE status or to place it in the tripped condition. Generally this Condition applies to functions that operate on two-out-of-three logic. Therefore, failure of one channel places the Function in a two-out-of-two configuration. One channel must be tripped to place the Function in a one-out-of-two configuration that satisfies redundancy requirements.

Failure to restore the inoperable channel to OPERABLE status or place it in the tripped condition within 72 hours requires the unit be placed in MODE 3 within the following 6 hours and MODE 4 within the next 6 hours.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.5.2.4 (continued)

which encompasses the ASME Code. The ASME Code provides the activities and Frequencies necessary to satisfy the requirements.

SR 3.5.2.5 and SR 3.5.2.6

These Surveillances demonstrate that each automatic ECCS valve actuates to the required position on an actual or simulated SI signal and that each ECCS pump capable of starting automatically starts on receipt of an actual or simulated SI signal. This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the required position under administrative controls. The 18 month Frequency is based on the need to perform these Surveillances under the conditions that apply during a unit outage and the potential for unplanned unit transients if the Surveillances were performed with the reactor at power.

The 18 month Frequency is also acceptable based on consideration of the design reliability (and confirming operating experience) of the equipment. The actuation logic is tested as part of ESF Actuation System testing, and equipment performance is monitored as part of the Inservice Testing Program.

SR 3.5.2.7

Proper throttle valve position is necessary for proper ECCS performance and to prevent pump runout and subsequent component damage. The Surveillance verifies each listed ECCS throttle valve is secured in the correct position. The 18 month Frequency is based on the same reasons as those stated in SR 3.5.2.5 and SR 3.5.2.6.

SR 3.5.2.8

Periodic inspections of the containment sump ~~suction inlet~~ components ensure that ~~it is~~ they are unrestricted and stay~~s~~ in proper operating condition. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and on the need to have access to the location. This Frequency has been found to be sufficient to detect abnormal degradation and is confirmed by operating experience.

BASES

BACKGROUND (continued)

b. Each air lock is OPERABLE, except as provided in LCO 3.6.2, "Containment Air Locks";

c. All equipment hatches are closed; and

d. The sealing mechanism associated with each penetration (e.g. welds, bellows, or O-rings) is OPERABLE.

APPLICABLE SAFETY ANALYSES

The safety design basis for the containment is that the containment must withstand the pressures and temperatures of the limiting DBA without exceeding the design leakage rate.

The DBAs that result in a challenge to containment OPERABILITY from high pressures and temperatures are a LOCA, a steam line break, and a rod ejection accident (REA) (Ref. 2). In addition, release of significant fission product radioactivity within containment can occur from a LOCA or REA. In the DBA analyses, it is assumed that the containment is OPERABLE such that, for the DBAs involving release of fission product radioactivity, release to the environment is controlled by the rate of containment leakage. The containment was designed with an allowable leakage rate of 0.1% of containment air weight per day (Ref. 3). This leakage rate, used to evaluate offsite doses resulting from accidents, is defined in 10 CFR 50, Appendix J, Option B (Ref. 1), as L_a: the maximum allowable containment leakage rate at the calculated peak containment internal pressure (P_a) resulting from the limiting design basis LOCA. The allowable leakage rate represented by L_a forms the basis for the acceptance criteria imposed on all containment leakage rate testing. L_a is assumed to be 0.1% of containment air weight per day in the safety analyses at P_a ~~= 44.1 psig~~, (Ref. 3).

Satisfactory leakage rate test results are a requirement for the establishment of containment OPERABILITY.

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

LCO

Containment OPERABILITY is maintained by limiting leakage to ≤ 1.0 L_a, except prior to the first startup after performing a required Containment Leakage Rate Testing Program leakage test. At this time the applicable leakage limits must be met.

(continued)

BASES

APPLICABLE SAFETY ANALYSES

The DBAs that result in a release of radioactive material within containment are a loss of coolant accident and a rod ejection accident (Ref. 3). In the analysis of each of these accidents, it is assumed that containment is OPERABLE such that release of fission products to the environment is controlled by the rate of containment leakage. The containment was designed with an allowable leakage rate of 0.1% of containment air weight per day (Ref. 2). This leakage rate is defined in 10 CFR 50, Appendix J, Option B (Ref. 1), as L_a = 0.1% of containment air weight per day, the maximum allowable containment leakage rate at the calculated peak containment internal pressure P_a ~~, 44.1 psig,~~ following a design basis LOCA. This allowable leakage rate forms the basis for the acceptance criteria imposed on the SRs associated with the air locks.

The containment air locks satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

Each containment air lock forms part of the containment pressure boundary. As part of the containment pressure boundary, the air lock safety function is related to control of the containment leakage rate resulting from a DBA. Thus, each air lock's structural integrity and leak tightness are essential to the successful mitigation of such an event.

Each air lock is required to be OPERABLE. For the air lock to be considered OPERABLE, the air lock interlock mechanism must be OPERABLE, the air lock must be in compliance with the Type B air lock leakage test, and both air lock doors must be OPERABLE. Opening or closing of the manways of the 7 ft personnel air lock is treated in the same manner as opening or closing of the associated door. The interlock allows only one air lock door of an air lock to be opened at one time. Operation of the manways of the 7 ft personnel air lock is controlled administratively. These provisions ensure that a gross breach of containment does not exist when containment is required to be OPERABLE. Closure of a single door in each air lock is sufficient to provide a leak tight barrier following postulated events. Nevertheless, both doors are kept closed when the air lock is not being used for entry into or exit from containment.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.4 Containment Pressure

BASES

BACKGROUND

Containment air partial pressure is a process variable that is monitored and controlled. The containment air partial pressure is maintained as a function of refueling water storage tank temperature and service water temperature according to Figure 3.6.4-1 of the LCO, to ensure that, following a Design Basis Accident (DBA), the containment would depressurize ~~in ≤ 60 minutes to subatmospheric~~ Replace with INSERT 5 conditions. Controlling containment partial pressure within prescribed limits also prevents the containment pressure from exceeding the containment design negative pressure differential with respect to the outside atmosphere in the event of an inadvertent actuation of the Quench Spray (QS) System. INSERT 6

The containment internal air partial pressure limits of Figure 3.6.4-1 are derived from the input conditions used in the containment DBA analyses. Limiting the containment internal air partial pressure and temperature in turn limits the pressure that could be expected following a DBA, thus ensuring containment OPERABILITY. Ensuring containment OPERABILITY limits leakage of fission product radioactivity from containment to the environment.

APPLICABLE SAFETY ANALYSES

Containment air partial pressure is an initial condition used in the containment DBA analyses to establish the maximum peak containment internal pressure. The limiting DBAs considered relative to containment pressure are the loss of coolant accident (LOCA) and steam line break (SLB). The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure transients. DBAs are assumed not to occur simultaneously or consecutively. The postulated DBAs are analyzed assuming degraded containment Engineered Safety Feature (ESF) systems (i.e., assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the QS System and one train of the Recirculation Spray System becoming inoperable). The containment analysis for the DBA (Ref. 1) shows that the maximum peak containment pressure results from the limiting design basis SLB.

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

The maximum design internal pressure for the containment is 45.0 psig. The LOCA and SLB analyses establish the limits for the containment air partial pressure operating range. The initial conditions used in the containment design basis LOCA analyses were an air partial pressure of ~~11.7~~ 12.3 psia and an air temperature of ~~120~~ 115°F. This resulted in a maximum peak containment internal pressure of ~~44.1~~ 42.7 psig, which is less than the maximum design internal pressure for the containment.

INSERT 14

The containment was also designed for an external pressure load of 9.2 psid (i.e., a design minimum pressure of 5.5 psia). The inadvertent actuation of the QS System was analyzed to determine the reduction in containment pressure (Ref. 1). The initial conditions used in the analysis were ~~8.43~~ 10.3 psia and ~~120~~ 115°F. This resulted in a minimum pressure inside containment of ~~7.07~~ 8.6 psia, which is considerably above the design minimum of 5.5 psia.

INSERT 7

For certain aspects of transient accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For the reflood phase calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the containment pressure response in accordance with 10 CFR 50, Appendix K (Ref. 2).

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to ~~0.5~~ 2.0 psig in 1 hour and does not exceed ~~0.5~~ 2.0 psig for the interval from 1 to ~~4~~ 6 hours following the Design Basis Accident (Ref. 3). Beyond ~~4~~ 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment.

Containment pressure satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

LCO

Maintaining containment pressure within the limits shown in Figure 3.6.4-1 of the LCO ensures that in the event of a DBA the resultant peak containment accident pressure will be maintained below the containment design pressure. These limits also prevent the containment pressure from exceeding

(continued)

BASES

LCO (continued)

the containment design negative pressure differential with respect to the outside atmosphere in the event of inadvertent actuation of the QS System. The LCO limits also ensure ~~the return to subatmospheric conditions within 60 minutes following a DBA.~~ Replace with Insert 8

APPLICABILITY

In MODES 1, 2, 3, and 4, a DBA could cause a release of radioactive material to containment. Since maintaining containment pressure within design basis limits is essential to ensure initial conditions assumed in the accident analyses are maintained, the LCO is applicable in MODES 1, 2, 3, and 4.

In MODES 5 and 6, the probability and consequences of these events are reduced due to the Reactor Coolant System pressure and temperature limitations of these MODES. Therefore, maintaining containment pressure within the limits of the LCO is not required in MODE 5 or 6.

ACTIONS

A.1

When containment air partial pressure is not within the limits of the LCO, containment pressure must be restored to within these limits within 1 hour. The Required Action is necessary to return operation to within the bounds of the containment analysis. The 1 hour Completion Time is consistent with the ACTIONS of LCO 3.6.1, "Containment," which requires that containment be restored to OPERABLE status within 1 hour.

B.1 and B.2

If containment air partial pressure cannot be restored to within limits within the required Completion Time, the unit must be brought to a MODE in which the LCO does not apply. To achieve this status, the unit must be brought to at least MODE 3 within 6 hours and to MODE 5 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required unit conditions from full power conditions in an orderly manner and without challenging unit systems.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.5 Containment Air Temperature

BASES

BACKGROUND

The containment structure serves to contain radioactive material that may be released from the reactor core following a Design Basis Accident (DBA). The containment average air temperature is limited during normal operation to preserve the initial conditions assumed in the accident analyses for a loss of coolant accident (LOCA) or steam line break (SLB).

The containment average air temperature limit is derived from the input conditions used in the containment functional analyses and the containment structure external pressure analyses. This LCO ensures that initial conditions assumed in the analysis of containment response to a DBA are not violated during unit operations. The total amount of energy to be removed from containment by the Containment Spray ~~and Cooling~~ systems during post accident conditions is dependent upon the energy released to the containment due to the event, as well as the initial containment temperature and pressure. The higher the initial temperature, the more energy which must be removed, resulting in a higher peak containment pressure and temperature. Exceeding containment design pressure may result in leakage greater than that assumed in the accident analysis. Operation with containment temperature in excess of the LCO limit violates an initial condition assumed in the accident analysis.

APPLICABLE SAFETY ANALYSES

Containment average air temperature is an initial condition used in the DBA analyses that establishes the containment environmental qualification operating envelope for both pressure and temperature. The limit for containment average air temperature ensures that operation is maintained within the assumptions used in the DBA analyses for containment (Ref. 1).

The limiting DBAs considered relative to containment OPERABILITY are the LOCA and SLB. The DBA LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure transients. No two DBAs are assumed to occur simultaneously or consecutively. The postulated DBAs are analyzed with regard to containment

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

Engineered Safety Feature (ESF) systems, assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the Quench Spray (QS) System and Recirculation Spray System being rendered inoperable. INSERT 11

The limiting DBA for the maximum peak containment air temperature is an SLB. The initial containment average air temperature assumed in the design basis analyses is ~~120~~ 115°F. This resulted in a maximum containment air temperature of 309 ~~357~~°F. The design temperature is 280°F.

The temperature upper limit is used to establish the environmental qualification operating envelope for containment. The maximum peak containment air temperature was calculated to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure the performance of safety related equipment inside containment (Ref. 2). Thermal analyses showed that the time interval during which the containment air temperature exceeded the containment design temperature was short enough that there would be no adverse effect on equipment inside containment assumed to mitigate the consequences of the DBA. Therefore, it is concluded that the calculated transient containment air temperature is acceptable for the DBA SLB.

The temperature upper limit is also used in the depressurization analyses to ensure that the minimum pressure limit is maintained following an inadvertent actuation of the QS System (Ref. 1).

The containment pressure transient is sensitive to the initial air mass in containment and, therefore, to the initial containment air temperature. The limiting DBA for establishing the maximum peak containment internal pressure is an SLB. The temperature upper limit is used in the SLB analysis to ensure that, in the event of an accident, the maximum containment internal pressure will not be exceeded.

Containment average air temperature satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

B 3.6 CONTAINMENT SYSTEMS

B 3.6.6 Quench Spray (QS) System

BASES

BACKGROUND

The QS System is designed to provide containment atmosphere cooling to limit post accident pressure and temperature in containment to less than the design values. The QS System, operating in conjunction with the Recirculation Spray (RS) System, is designed to cool and depressurize the containment structure ~~to subatmospheric pressure in less than 60 minutes~~ following a Design Basis Accident (DBA). Reduction of containment pressure and the iodine removal capability of the spray limit the release of fission product radioactivity from containment to the environment in the event of a DBA. Replace with Insert 5

The QS System consists of two separate trains of equal capacity, each capable of meeting the design bases. Each train includes a spray pump, a dedicated spray header, nozzles, valves, and piping. Each train is powered from a separate Engineered Safety Features (ESF) bus. The refueling water storage tank (RWST) supplies borated water to the QS System.

The QS System is actuated either automatically by a containment High-High pressure signal or manually. The QS System provides a spray of cold borated water into the upper regions of containment to reduce the containment pressure and temperature during a DBA. Each train of the QS System provides adequate spray coverage to meet the system design requirements for containment heat and iodine fission product removal. The QS System also provides flow to the Inside RS pumps to improve the net positive suction head available.

The Chemical Addition System supplies a sodium hydroxide (NaOH) solution into the spray. The resulting alkaline pH of the spray enhances the ability of the spray to scavenge iodine fission products from the containment atmosphere. The NaOH added to the spray also ensures an alkaline pH for the solution recirculated in the containment sump. The alkaline pH of the containment sump water minimizes the evolution of iodine and minimizes the occurrence of chloride and caustic stress corrosion on mechanical systems and components exposed to the fluid.

(continued)

BASES

BACKGROUND (continued)

The QS System is a containment ESF system. It is designed to ensure that the heat removal capability required during the post accident period can be attained. Operation of the QS System and RS System provides the required heat removal capability to limit post accident conditions to less than the containment design values and depressurize the containment structure ~~to subatmospheric pressure in ≤ 60 minutes~~ following a DBA.

The QS System limits the temperature and pressure that could be expected following a DBA and ensures that containment leakage is maintained consistent with the accident analysis.

APPLICABLE SAFETY ANALYSES

Replace with Insert 5

The limiting DBAs considered are the loss of coolant accident (LOCA) and the steam line break (SLB). The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure and temperature transients. No DBAs are assumed to occur simultaneously or consecutively. The postulated DBAs are analyzed, with respect to containment ESF Systems, assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the QS System and the RS System inoperable. Insert 11

During normal operation, the containment internal pressure is varied, along with other parameters, to maintain the capability to depressurize the containment ~~to a subatmospheric pressure in ≤ 60 minutes~~ after a DBA. This capability and the variation of containment pressure during a DBA are functions of the service water temperature, the RWST water temperature, and the containment air temperature.

The DBA analyses (Ref. 1) show ~~that~~ the maximum peak containment pressure of ~~44.9~~ 43.0 psig results from the SLB analysis and is calculated to be less than the containment design pressure. The maximum peak containment atmosphere temperature of ~~430~~ 309°F results from the SLB analysis and was ~~calculated~~ to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure OPERABILITY of safety related equipment inside containment (Ref. 2). Thermal analyses show that the time interval during which the containment atmosphere temperature exceeded the containment design temperature was short enough that there would be no adverse effect on equipment inside containment assumed to mitigate the consequences of the DBA.

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

Therefore, it is concluded that the calculated transient containment atmosphere temperatures are acceptable for the SLB.

The modeled QS System actuation from the containment analysis is based upon a response time associated with exceeding the containment High-High pressure signal setpoint to achieving full flow through the spray nozzles. A delayed response time initiation provides conservative analyses of peak calculated containment temperature and pressure responses. The QS System total response time of ~~71.1~~ 70 seconds after Containment Pressure - High High comprises the signal delay, diesel generator startup time, and system startup time, including pipe fill time.

For certain aspects of accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For these calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the calculated transient containment pressures in accordance with 10 CFR 50, Appendix K (Ref. 3).

Inadvertent actuation of the QS System is evaluated in the analysis, and the resultant reduction in containment pressure is calculated. The maximum calculated reduction in containment pressure results in containment pressures within the design containment minimum pressure.

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to ~~0.5~~ 2.0 psig in 1 hour and does not exceed ~~0.5~~ 2.0 psig for the interval from 1 to ~~4~~ 6 hours following the Design Basis Accident (Ref. 4). Beyond ~~4~~ 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment.

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

LCO

During a DBA, one train of the QS System is required to provide the heat removal capability assumed in the safety analyses for containment. In addition, one QS System train, with spray pH adjusted by the contents of the chemical addition tank, is required to scavenge iodine fission

(continued)

B 3.6 CONTAINMENT SYSTEMS

B 3.6.7 Recirculation Spray (RS) System

BASES

BACKGROUND

The RS System, operating in conjunction with the Quench Spray (QS) System, is designed to limit the post accident pressure and temperature in the containment to less than the design values and to depressurize the containment structure ~~to a subatmospheric pressure in less than 60 minutes~~ following a Design Basis Accident (DBA). The reduction of containment pressure and the removal of iodine from the containment atmosphere by the spray limit the release of fission product radioactivity from containment to the environment in the event of a DBA.

Replace with Insert 5

The RS System consists of two separate trains of equal capacity, each capable of meeting the design and accident analysis bases. Each train includes one RS subsystem outside containment and one RS subsystem inside containment. Each subsystem consists of one approximately 50% capacity spray pump, one spray cooler, one 180° coverage spray header, nozzles, valves, piping, instrumentation, and controls. Each outside RS subsystem also includes a casing cooling pump with its own valves, piping, instrumentation, and controls. The two outside RS subsystems' spray pumps are located outside containment and the two inside RS subsystems' spray pumps are located inside containment. Each RS train (one inside and one outside RS subsystem) is powered from a separate Engineered Safety Features (ESF) bus. Each train of the RS System provides adequate spray coverage to meet the system design requirements for containment heat and iodine fission product removal. Two spray pumps are required to provide 360° of containment spray coverage assumed in the accident analysis. One train of RS or two outside RS subsystems will provide the containment spray coverage and required flow.

The two casing cooling pumps and common casing cooling tank are designed to increase the net positive suction head (NPSH) available to the outside RS pumps by injecting cold water into the suction of the spray pumps. They are also beneficial to the containment depressurization analysis. The casing cooling tank contains at least 116,500 gal of chilled and borated water. Each casing cooling pump supplies one outside spray pump with cold borated water from the casing

(continued)

BASES

BACKGROUND (continued)

cooling tank. The casing cooling pumps are considered part of the outside RS subsystems. Each casing cooling pump is powered from a separate ESF bus.

The inside RS subsystem pump NPSH is increased by reducing the temperature of the water at the pump suction. Flow is diverted from the QS system to the suction of the inside RS pump on the same safety train as the quench spray pump supplying the water.

The RS System provides a spray of subcooled water into the upper regions of containment to reduce the containment pressure and temperature during a DBA. Upon receipt of a High-High containment pressure signal, the two casing cooling pumps start, the casing cooling discharge valves open, and the RS pump suction and discharge valves receive an open signal to assure the valves are open. ~~After a 400±5 second time delay, the inside RS pumps start, and after a 210±5 second time delay, the outside RS pumps start.~~ Replace with Insert 9 The RS pumps take suction from the containment sump and discharge through their respective spray coolers to the spray headers and into the containment atmosphere. Heat is transferred from the containment sump water to service water in the spray coolers.

The Chemical Addition System supplies a sodium hydroxide (NaOH) solution to the RWST water supplied to the suction of the QS System pumps. The NaOH added to the QS System spray ensures an alkaline pH for the solution recirculated in the containment sump. The resulting alkaline pH of the RS spray (pumped from the sump) enhances the ability of the spray to scavenge iodine fission products from the containment atmosphere. The alkaline pH of the containment sump water minimizes the evolution of iodine and minimizes the occurrence of chloride and caustic stress corrosion on mechanical systems and components exposed to the fluid.

The RS System is a containment ESF system. It is designed to ensure that the heat removal capability required during the post accident period can be attained. Operation of the QS and RS systems provides the required heat removal capability to limit post accident conditions to less than the containment design values and depressurize the containment structure ~~to subatmospheric pressure in < 60 minutes~~ Replace with Insert 5 following a DBA.

The RS System limits the temperature and pressure that could be expected following a DBA and ensures that containment leakage is maintained consistent with the accident analysis.

BASES

APPLICABLE SAFETY ANALYSES

The limiting DBAs considered are the ~~loss of coolant accident~~ (LOCA) and the ~~steam line break~~ (SLB). The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure and temperature transients; DBAs are assumed not to occur simultaneously or consecutively. The postulated DBAs are analyzed assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure for containment depressurization, resulting in one train of the QS and RS systems being rendered inoperable (Ref. 1). INSERT 11

The peak containment pressure following a high energy line break is affected by the initial total pressure and temperature of the containment atmosphere and the QS System operation. Maximizing the initial containment total pressure and average atmospheric temperature maximizes the calculated peak pressure. The heat removal effectiveness of the QS System spray is dependent on the temperature of the water in the ~~refueling water storage tank~~ (RWST). The time required to depressurize the containment and the capability to maintain it depressurized below atmospheric pressure depend on the functional performance of the QS and RS systems and the service water temperature. When the Service Water temperature is elevated, it is more difficult to depressurize the containment ~~within 60 minutes~~ since the heat removal effectiveness of the RS System is limited. Replace with INSERT 6

During normal operation, the containment internal pressure is varied to maintain the capability to depressurize the containment ~~to a subatmospheric pressure in less than 60 minutes~~ after a DBA. This capability and the variation of containment pressure are functions of service water temperature, RWST water temperature, and the containment air temperature.

The DBA analyses show that the maximum peak containment pressure of ~~44.9~~ 43.0 psig results from the SLB analysis and is calculated to be less than the containment design pressure. The maximum ~~357~~ 309°F peak containment atmosphere temperature results from the SLB analysis and is calculated to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure OPERABILITY of safety related equipment inside containment (Ref. 2). Thermal analyses show that the time interval during which

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

the containment atmosphere temperature exceeds the containment design temperature is short enough that there would be no adverse effect on equipment inside containment. Therefore, it is concluded that the calculated transient containment atmosphere temperatures are acceptable for the SLB and LOCA.

~~The RS System actuation model from the containment analysis is based upon a response time associated with exceeding the High-High containment pressure signal setpoint to achieving full flow through the RS System spray nozzles. A delay in response time initiation provides conservative analyses of peak calculated containment temperature and pressure. The RS System's total response time is determined by the delay timers and system startup time.~~

Replace with Insert 12

For certain aspects of accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For these calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the calculated transient containment pressures in accordance with 10 CFR 50, Appendix K (Ref. 3).

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to ~~0.5~~ 2.0 psig in 1 hour and does not exceed ~~0.5~~ 2.0 psig for the interval from 1 to ~~4~~ 6 hours following the Design Basis Accident (Ref. 4). Beyond ~~4~~ 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment.

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

LCO

During a DBA, one train (one inside and one outside RS subsystem in the same train) or two outside RS subsystems of the RS System are required to provide the minimum heat removal capability assumed in the safety analysis. To ensure that this requirement is met, four RS subsystems and the casing cooling tank must be OPERABLE. This will ensure that at least one train will operate assuming the worst case single failure occurs, which is no offsite power and the loss of one emergency diesel generator. Inoperability of the

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.7.4 (continued)

it involves verification, through a system walkdown, that those valves outside containment and capable of potentially being mispositioned are in the correct position.

SR 3.6.7.5

Verifying that each RS and casing cooling pump's developed head at the flow test point is greater than or equal to the required developed head ensures that these pumps' performance has not degraded during the cycle. Flow and differential head are normal tests of centrifugal pump performance required by the ASME Code (Ref. 5). Since the RS System pumps cannot be tested with flow through the spray headers, they are tested on recirculation flow. This test confirms one point on the pump design curve and is indicative of overall performance. Such inservice tests confirm component OPERABILITY, trend performance, and detect incipient failures by indicating abnormal performance. The Frequency of this SR is in accordance with the Inservice Testing Program.

SR 3.6.7.6

These SRs ensure that each automatic valve actuates and that the ~~RS System and~~ casing cooling pumps start upon receipt of an actual or simulated High-High containment pressure signal. ~~Start delay times are also verified for the RS System pumps.~~ This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the required position under administrative controls. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the Surveillance when performed at the 18 month Frequency. Therefore, the Frequency was considered to be acceptable from a reliability standpoint.

Replace with Insert 10

Insert 13
SR 3.6.7.7

SR 3.6.7.~~7~~ 8

This SR ensures that each spray nozzle is unobstructed and that spray coverage of the containment will meet its design bases objective. Either an inspection of the nozzles or an air or smoke test is performed through each spray header. Due

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.7.~~7~~ 8 (continued)

to the passive design of the spray header and its normally dry state, a test performed following maintenance which could result in nozzle blockage is considered adequate for detecting obstruction of the nozzles.

REFERENCES

1. UFSAR, Section 6.2.
2. 10 CFR 50.49.
3. 10 CFR 50, Appendix K.
4. UFSAR, Section 15.4.1.7.
5. ASME Code for Operation and Maintenance of Nuclear Power Plants.

ATTACHMENT 5

PROPOSED TECHNICAL SPECIFICATION CHANGE AND SUPPORTING SAFETY ANALYSES REVISIONS TO ADDRESS GENERIC SAFETY ISSUE 191

TYPED TECHNICAL SPECIFICATION BASES PAGES

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

1. Safety Injection (continued)

f. g. Safety Injection-High Steam Flow in Two Steam Lines Coincident With T_{avg}-Low Low or Coincident With Steam Line Pressure-Low (continued)

With the transmitters located inside the containment (T_{avg}) or near the steam lines (High Steam Flow), it is possible for them to experience adverse steady state environmental conditions during an SLB event. The trip setpoint reflects only steady state instrument uncertainties.

This Function must be OPERABLE in MODES 1, 2, and 3 (above P-12) when a secondary side break or stuck open valve could result in the rapid depressurization of the steam line(s). This signal may be manually blocked by the operator when below the P-12 setpoint. Above P-12, this Function is automatically unblocked. This Function is not required OPERABLE below P-12 because the reactor is not critical, so steam line break is not a concern. SLB may be addressed by Containment Pressure High (inside containment) or by High Steam Flow in Two Steam Lines coincident with Steam Line Pressure-Low, for Steam Line Isolation, followed by High Differential Pressure Between Two Steam Lines, for SI. This Function is not required to be OPERABLE in MODE 4, 5, or 6 because there is insufficient energy in the secondary side of the unit to cause an accident.

2. Containment Spray Systems

The Containment Spray Systems (Quench Spray (QS) and Recirculation Spray (RS)) provide four primary functions:

1. Lowers containment pressure and temperature after an HELB in containment;
2. Reduces the amount of radioactive iodine in the containment atmosphere;
3. Adjusts the pH of the water in the containment sump after a large break LOCA; and
4. Remove heat from containment.

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

These functions are necessary to:

- Ensure the pressure boundary integrity of the containment structure;
- Limit the release of radioactive iodine to the environment in the event of a failure of the containment structure; and
- Minimize corrosion of the components and systems inside containment following a LOCA.

The containment spray actuation signal starts the QS pumps and aligns the discharge of the pumps to the containment spray nozzle headers in the upper levels of containment. Water is initially drawn from the RWST by the QS pumps and mixed with a sodium hydroxide solution from the chemical addition tank. When the RWST level reaches the low setpoint coincident with Containment Pressure—High High, the RS pumps receive a start signal. The outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. Water is drawn from the containment sump through heat exchangers and discharged to the RS nozzle headers. When the RWST reaches the low low level setpoint, the Low Head Safety Injection pump suctions are shifted to the containment sump. Containment spray is actuated manually or by Containment Pressure—High High signal. RS is actuated manually or by RWST Level—Low coincident with Containment Pressure—High High.

a. Containment Spray—Manual Initiation

The operator can initiate containment spray at any time from the control room by simultaneously turning two containment spray actuation switches in the same train. Because an inadvertent actuation of containment spray could have such serious consequences, two switches must be turned simultaneously to initiate containment spray. There are two sets of two switches each in the control room.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

a. Containment Spray-Manual Initiation (continued)

Simultaneously turning the two switches in either set will actuate containment spray in both trains in the same manner as the automatic actuation signal. Two Manual Initiation switches in each train are required to be OPERABLE to ensure no single failure disables the Manual Initiation Function. Note that Manual Initiation of containment spray also actuates Phase B containment isolation.

b. Containment Spray-Automatic Actuation Logic and Actuation Relays

Automatic actuation logic and actuation relays consist of the same features and operate in the same manner as described for ESFAS Function 1.b.

Manual and automatic initiation of containment spray must be OPERABLE in MODES 1, 2, and 3 when there is a potential for an accident to occur, and sufficient energy exists in the primary or secondary systems to pose a threat to containment integrity due to overpressure conditions. Manual initiation is also required in MODE 4, even though automatic actuation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA. However, because of the large number of components actuated on a containment spray, actuation is simplified by the use of the manual actuation switches. Automatic actuation logic and actuation relays must be OPERABLE in MODE 4 to support system manual initiation. In MODES 5 and 6, there is insufficient energy in the primary and secondary systems to result in containment overpressure. In MODES 5 and 6, there is also adequate time for the operators to evaluate unit conditions and respond, to mitigate the consequences of abnormal conditions by manually starting individual components.

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

c. Containment Spray-Containment Pressure

This signal provides protection against a LOCA or an SLB inside containment. The transmitters (d/p cells) are located outside of containment with the sensing line (high pressure side of the transmitter) located inside containment. The transmitters and electronics are located outside of containment. Thus, they will not experience any adverse environmental conditions and the Allowable Value reflects only steady state instrument uncertainties.

This is one of few Functions that requires the bistable output to energize to perform its required action. It is not desirable to have a loss of power actuate containment spray, since the consequences of an inadvertent actuation of containment spray could be serious. Note that this Function also has the inoperable channel placed in bypass rather than trip to decrease the probability of an inadvertent actuation.

North Anna uses four channels in a two-out-of-four logic configuration and the Containment Pressure—High High Setpoint Actuates Containment Spray Systems. Since containment pressure is not used for control, this arrangement exceeds the minimum redundancy requirements. Additional redundancy is warranted because this Function is energize to trip. Containment Pressure—High High must be OPERABLE in MODES 1, 2, and 3 when there is sufficient energy in the primary and secondary sides to pressurize the containment following a pipe break. In MODES 4, 5, and 6, there is insufficient energy in the primary and secondary sides to pressurize the containment and reach the Containment Pressure—High High setpoints.

d. RWST Level—Low Coincident with Containment Pressure—High High

This signal starts the RS system to provide protection against a LOCA inside containment. The Containment Pressure—High High (ESFAS Function 2.c) signal aligns the RS system for spray flow delivery (e.g., opens isolation valves) but does not start the

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

2. Containment Spray Systems (continued)

d. RWST Level-Low Coincident with Containment Pressure-High High (continued)

RS pumps. The RWST Level-Low coincident with Containment Pressure-High High provides the automatic start signal for the inside RS and outside RS pumps. Once the coincidence trip is satisfied, the outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. The delay time is sufficient to avoid simultaneous starting of the RS pumps on the same emergency diesel generator. This ESFAS function ensures that adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements following a LOCA. The RS system is not required for SLB mitigation.

Automatic initiation of RS must be OPERABLE in MODES 1, 2, and 3 when there is a potential for an accident to occur, and sufficient energy exists in the primary and secondary systems to pose a threat to containment integrity due to overpressure conditions. The requirement for automatic initiation of RWST Level-Low to be operable in MODES 1, 2, and 3 is consistent with the operability requirements for Containment Pressure-High High. Manual initiation of the RS system is required in MODE 4, even though automatic initiation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA. In MODES 5 and 6, there is insufficient energy in the primary and secondary systems to result in containment overpressure. In MODES 5 and 6, there is also adequate time for the operators to evaluate unit conditions and respond to mitigate the consequences of abnormal conditions by manually starting individual components. An operator can initiate RS at any time from the control room by using the pump control switch. The manual function would be used only when adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements.

BASES

APPLICABLE SAFETY ANALYSES, LCO, AND APPLICABILITY

3. Containment Isolation (continued)

a. Containment Isolation—Phase A Isolation (continued)

Manual and automatic initiation of Phase A Containment Isolation must be OPERABLE in MODES 1, 2, and 3, when there is a potential for an accident to occur. Manual initiation is also required in MODE 4 even though automatic actuation is not required. In this MODE, adequate time is available to manually actuate required components in the event of a DBA, but because of the large number of components actuated on a Phase A Containment Isolation, actuation is simplified by the use of the manual actuation switches. Automatic actuation logic and actuation relays must be OPERABLE in MODE 4 to support system manual initiation. In MODES 5 and 6, there is insufficient energy in the primary or secondary systems to pressurize the containment to require Phase A Containment Isolation. There also is adequate time for the operator to evaluate unit conditions and manually actuate individual isolation valves in response to abnormal or accident conditions.

(3) Phase A Isolation—Safety Injection

Phase A Containment Isolation is also initiated by all Functions that initiate SI. The Phase A Containment Isolation requirements for these Functions are the same as the requirements for their SI function. Therefore, the requirements are not repeated in Table 3.3.2-1. Instead, Function 1, SI, is referenced for all initiating Functions and requirements.

b. Containment Isolation—Phase B Isolation

Phase B Containment Isolation is accomplished by Manual Initiation, Automatic Actuation Logic and Actuation Relays, and by Containment Pressure channels (the same channels that actuate Containment Spray Systems, Function 2). The Containment Pressure trip of Phase B Containment Isolation is energized to trip in order to minimize the potential of spurious trips that may damage the RCPs.

(1) Phase B Isolation—Manual Initiation

BASES

ACTIONS

D.1, D.2.1, and D.2.2 (continued)

- High Steam Flow in Two Steam Lines Coincident With T_{avg}–Low Low or Coincident With Steam Line Pressure–Low;
- Containment Pressure–Intermediate High High;
- SG Water Level–Low Low;
- SG Water Level–High High (P-14); and
- RWST Level–Low Coincident With Containment Pressure High High.

If one channel is inoperable, 72 hours are allowed to restore the channel to OPERABLE status or to place it in the tripped condition. Generally this Condition applies to functions that operate on two-out-of-three logic. Therefore, failure of one channel places the Function in a two-out-of-two configuration. One channel must be tripped to place the Function in a one-out-of-two configuration that satisfies redundancy requirements.

Failure to restore the inoperable channel to OPERABLE status or place it in the tripped condition within 72 hours requires the unit be placed in MODE 3 within the following 6 hours and MODE 4 within the next 6 hours.

The allowed Completion Times are reasonable, based on operating experience, to reach the required unit conditions from full power conditions in an orderly manner and without challenging unit systems. In MODE 4, these Functions are no longer required OPERABLE.

The Required Actions are modified by a Note that allows the inoperable channel to be bypassed for up to 12 hours for surveillance testing of other channels. The 72 hours allowed to restore the channel to OPERABLE status or to place the inoperable channel in the tripped condition, and the 12 hours allowed for testing, are justified in Reference 8.

E.1, E.2.1, and E.2.2

Condition E applies to:

- Containment Spray Containment Pressure–High High; and

BASES

SURVEILLANCE REQUIREMENTS

SR 3.5.2.4 (continued)

which encompasses the ASME Code. The ASME Code provides the activities and Frequencies necessary to satisfy the requirements.

SR 3.5.2.5 and SR 3.5.2.6

These Surveillances demonstrate that each automatic ECCS valve actuates to the required position on an actual or simulated SI signal and that each ECCS pump capable of starting automatically starts on receipt of an actual or simulated SI signal. This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the required position under administrative controls. The 18 month Frequency is based on the need to perform these Surveillances under the conditions that apply during a unit outage and the potential for unplanned unit transients if the Surveillances were performed with the reactor at power.

The 18 month Frequency is also acceptable based on consideration of the design reliability (and confirming operating experience) of the equipment. The actuation logic is tested as part of ESF Actuation System testing, and equipment performance is monitored as part of the Inservice Testing Program.

SR 3.5.2.7

Proper throttle valve position is necessary for proper ECCS performance and to prevent pump runout and subsequent component damage. The Surveillance verifies each listed ECCS throttle valve is secured in the correct position. The 18 month Frequency is based on the same reasons as those stated in SR 3.5.2.5 and SR 3.5.2.6.

SR 3.5.2.8

Periodic inspections of the containment sump components ensure that they are unrestricted and stay in proper operating condition. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and on the need to have access to the location. This Frequency has been found to be sufficient to detect abnormal degradation and is confirmed by operating experience.

BASES

BACKGROUND (continued)

b. Each air lock is OPERABLE, except as provided in LCO 3.6.2, "Containment Air Locks";

c. All equipment hatches are closed; and

d. The sealing mechanism associated with each penetration (e.g. welds, bellows, or O-rings) is OPERABLE.

APPLICABLE SAFETY ANALYSES

The safety design basis for the containment is that the containment must withstand the pressures and temperatures of the limiting DBA without exceeding the design leakage rate.

The DBAs that result in a challenge to containment OPERABILITY from high pressures and temperatures are a LOCA, a steam line break, and a rod ejection accident (REA) (Ref. 2). In addition, release of significant fission product radioactivity within containment can occur from a LOCA or REA. In the DBA analyses, it is assumed that the containment is OPERABLE such that, for the DBAs involving release of fission product radioactivity, release to the environment is controlled by the rate of containment leakage. The containment was designed with an allowable leakage rate of 0.1% of containment air weight per day (Ref. 3). This leakage rate, used to evaluate offsite doses resulting from accidents, is defined in 10 CFR 50, Appendix J, Option B (Ref. 1), as L_a: the maximum allowable containment leakage rate at the calculated peak containment internal pressure (P_a) resulting from the limiting design basis LOCA. The allowable leakage rate represented by L_a forms the basis for the acceptance criteria imposed on all containment leakage rate testing. L_a is assumed to be 0.1% of containment air weight per day in the safety analyses at P_a (Ref. 3).

Satisfactory leakage rate test results are a requirement for the establishment of containment OPERABILITY.

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

LCO

Containment OPERABILITY is maintained by limiting leakage to $\leq 1.0\ L_a$, except prior to the first startup after performing a required Containment Leakage Rate Testing Program leakage test. At this time the applicable leakage limits must be met.

(continued)

BASES

APPLICABLE SAFETY ANALYSES

The DBAs that result in a release of radioactive material within containment are a loss of coolant accident and a rod ejection accident (Ref. 3). In the analysis of each of these accidents, it is assumed that containment is OPERABLE such that release of fission products to the environment is controlled by the rate of containment leakage. The containment was designed with an allowable leakage rate of 0.1% of containment air weight per day (Ref. 2). This leakage rate is defined in 10 CFR 50, Appendix J, Option B (Ref. 1), as L_a = 0.1% of containment air weight per day, the maximum allowable containment leakage rate at the calculated peak containment internal pressure P_a following a design basis LOCA. This allowable leakage rate forms the basis for the acceptance criteria imposed on the SRs associated with the air locks.

The containment air locks satisfy Criterion 3 of 10 CFR 50.36(c)(2)(ii).

LCO

Each containment air lock forms part of the containment pressure boundary. As part of the containment pressure boundary, the air lock safety function is related to control of the containment leakage rate resulting from a DBA. Thus, each air lock's structural integrity and leak tightness are essential to the successful mitigation of such an event.

Each air lock is required to be OPERABLE. For the air lock to be considered OPERABLE, the air lock interlock mechanism must be OPERABLE, the air lock must be in compliance with the Type B air lock leakage test, and both air lock doors must be OPERABLE. Opening or closing of the manways of the 7 ft personnel air lock is treated in the same manner as opening or closing of the associated door. The interlock allows only one air lock door of an air lock to be opened at one time. Operation of the manways of the 7 ft personnel air lock is controlled administratively. These provisions ensure that a gross breach of containment does not exist when containment is required to be OPERABLE. Closure of a single door in each air lock is sufficient to provide a leak tight barrier following postulated events. Nevertheless, both doors are kept closed when the air lock is not being used for entry into or exit from containment.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.4 Containment Pressure

BASES

BACKGROUND

Containment air partial pressure is a process variable that is monitored and controlled. The containment air partial pressure is maintained as a function of refueling water storage tank temperature and service water temperature according to Figure 3.6.4-1 of the LCO, to ensure that, following a Design Basis Accident (DBA), the containment would depressurize to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours. Controlling containment partial pressure within prescribed limits also prevents the containment pressure from exceeding the containment design negative pressure differential with respect to the outside atmosphere in the event of an inadvertent actuation of the Quench Spray (QS) System. Controlling containment air partial pressure limits within prescribed limits ensures adequate net positive suction head (NPSH) for the recirculation spray and low head safety injection pumps following a DBA.

The containment internal air partial pressure limits of Figure 3.6.4-1 are derived from the input conditions used in the containment DBA analyses. Limiting the containment internal air partial pressure and temperature in turn limits the pressure that could be expected following a DBA, thus ensuring containment OPERABILITY. Ensuring containment OPERABILITY limits leakage of fission product radioactivity from containment to the environment.

APPLICABLE SAFETY ANALYSES

Containment air partial pressure is an initial condition used in the containment DBA analyses to establish the maximum peak containment internal pressure. The limiting DBAs considered relative to containment pressure are the loss of coolant accident (LOCA) and steam line break (SLB). The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure transients. DBAs are assumed not to occur simultaneously or consecutively. The postulated DBAs are analyzed assuming degraded containment Engineered Safety Feature (ESF) systems (i.e., assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the QS System and

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

one train of the Recirculation Spray System becoming inoperable). The containment analysis for the DBA (Ref. 1) shows that the maximum peak containment pressure results from the limiting design basis SLB.

The maximum design internal pressure for the containment is 45.0 psig. The LOCA and SLB analyses establish the limits for the containment air partial pressure operating range. The initial conditions used in the containment design basis LOCA analyses were an air partial pressure of 12.3 psia and an air temperature of 115°F. This resulted in a maximum peak containment internal pressure of 42.7 psig, which is less than the maximum design internal pressure for the containment. The SLB analysis resulted in a maximum peak containment internal pressure of 43.0 psig, which is less than the maximum design internal pressure for the containment.

The containment was also designed for an external pressure load of 9.2 psid (i.e., a design minimum pressure of 5.5 psia). The inadvertent actuation of the QS System was analyzed to determine the reduction in containment pressure (Ref. 1). The initial conditions used in the analysis were 10.3 psia and 115°F. This resulted in a minimum pressure inside containment of 8.6 psia, which is considerably above the design minimum of 5.5 psia.

Controlling containment air partial pressure limits within prescribed limits ensures adequate NPSH for the recirculation spray and low head safety injection pumps following a DBA. The minimum containment air partial pressure is an initial condition for the NPSH analyses.

For certain aspects of transient accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For the reflood phase calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the containment pressure response in accordance with 10 CFR 50, Appendix K (Ref. 2).

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to 2.0 psig in 1 hour and does not exceed 2.0 psig

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)	for the interval from 1 to 6 hours following the Design Basis Accident (Ref. 3). Beyond 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment. Containment pressure satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).
LCO	Maintaining containment pressure within the limits shown in Figure 3.6.4-1 of the LCO ensures that in the event of a DBA the resultant peak containment accident pressure will be maintained below the containment design pressure. These limits also prevent the containment pressure from exceeding the containment design negative pressure differential with respect to the outside atmosphere in the event of inadvertent actuation of the QS System. The LCO limits also ensure the containment structure will depressurize to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a DBA.
APPLICABILITY	In MODES 1, 2, 3, and 4, a DBA could cause a release of radioactive material to containment. Since maintaining containment pressure within design basis limits is essential to ensure initial conditions assumed in the accident analyses are maintained, the LCO is applicable in MODES 1, 2, 3, and 4. In MODES 5 and 6, the probability and consequences of these events are reduced due to the Reactor Coolant System pressure and temperature limitations of these MODES. Therefore, maintaining containment pressure within the limits of the LCO is not required in MODE 5 or 6.
ACTIONS	A.1 When containment air partial pressure is not within the limits of the LCO, containment pressure must be restored to within these limits within 1 hour. The Required Action is necessary to return operation to within the bounds of the containment analysis. The 1 hour Completion Time is consistent with the ACTIONS of LCO 3.6.1, "Containment," which requires that containment be restored to OPERABLE status within 1 hour.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.5 Containment Air Temperature

BASES

BACKGROUND

The containment structure serves to contain radioactive material that may be released from the reactor core following a Design Basis Accident (DBA). The containment average air temperature is limited during normal operation to preserve the initial conditions assumed in the accident analyses for a loss of coolant accident (LOCA) or steam line break (SLB).

The containment average air temperature limit is derived from the input conditions used in the containment functional analyses and the containment structure external pressure analyses. This LCO ensures that initial conditions assumed in the analysis of containment response to a DBA are not violated during unit operations. The total amount of energy to be removed from containment by the Containment Spray systems during post accident conditions is dependent upon the energy released to the containment due to the event, as well as the initial containment temperature and pressure. The higher the initial temperature, the more energy which must be removed, resulting in a higher peak containment pressure and temperature. Exceeding containment design pressure may result in leakage greater than that assumed in the accident analysis. Operation with containment temperature in excess of the LCO limit violates an initial condition assumed in the accident analysis.

APPLICABLE SAFETY ANALYSES

Containment average air temperature is an initial condition used in the DBA analyses that establishes the containment environmental qualification operating envelope for both pressure and temperature. The limit for containment average air temperature ensures that operation is maintained within the assumptions used in the DBA analyses for containment (Ref. 1).

The limiting DBAs considered relative to containment OPERABILITY are the LOCA and SLB. The DBA LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure transients. No two DBAs are assumed to occur simultaneously or consecutively. The postulated DBAs are analyzed with regard to containment

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

Engineered Safety Feature (ESF) systems, assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the Quench Spray (QS) System and Recirculation Spray System being rendered inoperable. The postulated SLB events are analyzed without credit for the RS system.

The limiting DBA for the maximum peak containment air temperature is an SLB. The initial containment average air temperature assumed in the design basis analyses is 115°F. This resulted in a maximum containment air temperature of 309°F. The design temperature is 280°F.

The temperature upper limit is used to establish the environmental qualification operating envelope for containment. The maximum peak containment air temperature was calculated to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure the performance of safety related equipment inside containment (Ref. 2). Thermal analyses showed that the time interval during which the containment air temperature exceeded the containment design temperature was short enough that there would be no adverse effect on equipment inside containment assumed to mitigate the consequences of the DBA. Therefore, it is concluded that the calculated transient containment air temperature is acceptable for the DBA SLB.

The temperature upper limit is also used in the depressurization analyses to ensure that the minimum pressure limit is maintained following an inadvertent actuation of the QS System (Ref. 1).

The containment pressure transient is sensitive to the initial air mass in containment and, therefore, to the initial containment air temperature. The limiting DBA for establishing the maximum peak containment internal pressure is an SLB. The temperature upper limit is used in the SLB analysis to ensure that, in the event of an accident, the maximum containment internal pressure will not be exceeded.

Containment average air temperature satisfies Criterion 2 of 10 CFR 50.36(c)(2)(ii).

B 3.6 CONTAINMENT SYSTEMS

B 3.6.6 Quench Spray (QS) System

BASES

BACKGROUND

The QS System is designed to provide containment atmosphere cooling to limit post accident pressure and temperature in containment to less than the design values. The QS System, operating in conjunction with the Recirculation Spray (RS) System, is designed to cool and depressurize the containment structure to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a Design Basis Accident (DBA). Reduction of containment pressure and the iodine removal capability of the spray limit the release of fission product radioactivity from containment to the environment in the event of a DBA.

The QS System consists of two separate trains of equal capacity, each capable of meeting the design bases. Each train includes a spray pump, a dedicated spray header, nozzles, valves, and piping. Each train is powered from a separate Engineered Safety Features (ESF) bus. The refueling water storage tank (RWST) supplies borated water to the QS System.

The QS System is actuated either automatically by a containment High-High pressure signal or manually. The QS System provides a spray of cold borated water into the upper regions of containment to reduce the containment pressure and temperature during a DBA. Each train of the QS System provides adequate spray coverage to meet the system design requirements for containment heat and iodine fission product removal. The QS System also provides flow to the Inside RS pumps to improve the net positive suction head available.

The Chemical Addition System supplies a sodium hydroxide (NaOH) solution into the spray. The resulting alkaline pH of the spray enhances the ability of the spray to scavenge iodine fission products from the containment atmosphere. The NaOH added to the spray also ensures an alkaline pH for the solution recirculated in the containment sump. The alkaline pH of the containment sump water minimizes the evolution of iodine and minimizes the occurrence of chloride and caustic stress corrosion on mechanical systems and components exposed to the fluid.

(continued)

BASES

BACKGROUND (continued)

The QS System is a containment ESF system. It is designed to ensure that the heat removal capability required during the post accident period can be attained. Operation of the QS System and RS System provides the required heat removal capability to limit post accident conditions to less than the containment design values and depressurize the containment structure to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a DBA.

The QS System limits the temperature and pressure that could be expected following a DBA and ensures that containment leakage is maintained consistent with the accident analysis.

APPLICABLE SAFETY ANALYSES

The limiting DBAs considered are the loss of coolant accident (LOCA) and the steam line break (SLB). The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure and temperature transients. No DBAs are assumed to occur simultaneously or consecutively. The postulated DBAs are analyzed, with respect to containment ESF Systems, assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure, resulting in one train of the QS System and the RS System inoperable. The postulated SLB events are analyzed without credit for the RS system.

During normal operation, the containment internal pressure is varied, along with other parameters, to maintain the capability to depressurize the containment to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours after a DBA. This capability and the variation of containment pressure during a DBA are functions of the service water temperature, the RWST water temperature, and the containment air temperature.

The DBA analyses (Ref. 1) show that the maximum peak containment pressure of 43.0 psig results from the SLB analysis and is calculated to be less than the containment design pressure. The maximum peak containment atmosphere temperature of 309°F results from the SLB analysis and was calculated to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure OPERABILITY of safety related equipment inside containment (Ref. 2). Thermal analyses show that the time interval during which the containment atmosphere temperature

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

exceeded the containment design temperature was short enough that there would be no adverse effect on equipment inside containment assumed to mitigate the consequences of the DBA.

Therefore, it is concluded that the calculated transient containment atmosphere temperatures are acceptable for the SLB.

The modeled QS System actuation from the containment analysis is based upon a response time associated with exceeding the containment High-High pressure signal setpoint to achieving full flow through the spray nozzles. A delayed response time initiation provides conservative analyses of peak calculated containment temperature and pressure responses. The QS System total response time of 70 seconds after Containment Pressure–High High comprises the signal delay, diesel generator startup time, and system startup time, including pipe fill time.

For certain aspects of accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For these calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the calculated transient containment pressures in accordance with 10 CFR 50, Appendix K (Ref. 3).

Inadvertent actuation of the QS System is evaluated in the analysis, and the resultant reduction in containment pressure is calculated. The maximum calculated reduction in containment pressure results in containment pressures within the design containment minimum pressure.

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to 2.0 psig in 1 hour and does not exceed 2.0 psig for the interval from 1 to 6 hours following the Design Basis Accident (Ref. 4). Beyond 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment.

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

B 3.6 CONTAINMENT SYSTEMS

B 3.6.7 Recirculation Spray (RS) System

BASES

BACKGROUND

The RS System, operating in conjunction with the Quench Spray (QS) System, is designed to limit the post accident pressure and temperature in the containment to less than the design values and to depressurize the containment structure to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a Design Basis Accident (DBA). The reduction of containment pressure and the removal of iodine from the containment atmosphere by the spray limit the release of fission product radioactivity from containment to the environment in the event of a DBA.

The RS System consists of two separate trains of equal capacity, each capable of meeting the design and accident analysis bases. Each train includes one RS subsystem outside containment and one RS subsystem inside containment. Each subsystem consists of one approximately 50% capacity spray pump, one spray cooler, one 180° coverage spray header, nozzles, valves, piping, instrumentation, and controls. Each outside RS subsystem also includes a casing cooling pump with its own valves, piping, instrumentation, and controls. The two outside RS subsystems' spray pumps are located outside containment and the two inside RS subsystems' spray pumps are located inside containment. Each RS train (one inside and one outside RS subsystem) is powered from a separate Engineered Safety Features (ESF) bus. Each train of the RS System provides adequate spray coverage to meet the system design requirements for containment heat and iodine fission product removal. Two spray pumps are required to provide 360° of containment spray coverage assumed in the accident analysis. One train of RS or two outside RS subsystems will provide the containment spray coverage and required flow.

The two casing cooling pumps and common casing cooling tank are designed to increase the net positive suction head (NPSH) available to the outside RS pumps by injecting cold water into the suction of the spray pumps. They are also beneficial to the containment depressurization analysis. The casing cooling tank contains at least 116,500 gal of chilled and borated water. Each casing cooling pump supplies one outside spray pump with cold borated water from the casing

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BASES

BACKGROUND (continued)

cooling tank. The casing cooling pumps are considered part of the outside RS subsystems. Each casing cooling pump is powered from a separate ESF bus.

The inside RS subsystem pump NPSH is increased by reducing the temperature of the water at the pump suction. Flow is diverted from the QS system to the suction of the inside RS pump on the same safety train as the quench spray pump supplying the water.

The RS System provides a spray of subcooled water into the upper regions of containment to reduce the containment pressure and temperature during a DBA. Upon receipt of a High-High containment pressure signal, the two casing cooling pumps start, the casing cooling discharge valves open, and the RS pump suction and discharge valves receive an open signal to assure the valves are open. Refueling water storage tank (RWST) Level—Low coincident with Containment Pressure—High High provides the automatic start signal for the inside RS and outside RS pumps. Once the coincidence logic is satisfied, the outside RS pumps start immediately and the inside RS pumps start after a 120-second delay. The delay time is sufficient to avoid simultaneous starting of the RS pumps on the same emergency diesel generator. The coincident trip ensures that adequate water inventory is present in the containment sump to meet the RS sump strainer functional requirements following a loss of coolant accident (LOCA). The RS system is not required for steam line break (SLB) mitigation. The RS pumps take suction from the containment sump and discharge through their respective spray coolers to the spray headers and into the containment atmosphere. Heat is transferred from the containment sump water to service water in the spray coolers.

The Chemical Addition System supplies a sodium hydroxide (NaOH) solution to the RWST water supplied to the suction of the QS System pumps. The NaOH added to the QS System spray ensures an alkaline pH for the solution recirculated in the containment sump. The resulting alkaline pH of the RS spray (pumped from the sump) enhances the ability of the spray to scavenge iodine fission products from the containment atmosphere. The alkaline pH of the containment sump water minimizes the evolution of iodine and minimizes the occurrence of chloride and caustic stress corrosion on mechanical systems and components exposed to the fluid.

(continued)

BASES

BACKGROUND (continued)

The RS System is a containment ESF system. It is designed to ensure that the heat removal capability required during the post accident period can be attained. Operation of the QS and RS systems provides the required heat removal capability to limit post accident conditions to less than the containment design values and depressurize the containment structure to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours following a DBA.

The RS System limits the temperature and pressure that could be expected following a DBA and ensures that containment leakage is maintained consistent with the accident analysis.

APPLICABLE SAFETY ANALYSES

The limiting DBAs considered are the LOCA and the SLB. The LOCA and SLB are analyzed using computer codes designed to predict the resultant containment pressure and temperature transients; DBAs are assumed not to occur simultaneously or consecutively. The postulated DBAs are analyzed assuming no offsite power and the loss of one emergency diesel generator, which is the worst case single active failure for containment depressurization, resulting in one train of the QS and RS systems being rendered inoperable (Ref. 1). The postulated SLB events are analyzed without credit for the RS system.

The peak containment pressure following a high energy line break is affected by the initial total pressure and temperature of the containment atmosphere and the QS System operation. Maximizing the initial containment total pressure and average atmospheric temperature maximizes the calculated peak pressure. The heat removal effectiveness of the QS System spray is dependent on the temperature of the water in the RWST. The time required to depressurize the containment and the capability to maintain it depressurized below atmospheric pressure depend on the functional performance of the QS and RS systems and the service water temperature. When the Service Water temperature is elevated, it is more difficult to depressurize the containment to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours since the heat removal effectiveness of the RS System is limited.

During normal operation, the containment internal pressure is varied to maintain the capability to depressurize the containment to less than 2.0 psig in 1 hour and to subatmospheric pressure within 6 hours after a DBA. This

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BASES

APPLICABLE SAFETY ANALYSES (continued)

capability and the variation of containment pressure are functions of service water temperature, RWST water temperature, and the containment air temperature.

The DBA analyses show that the maximum peak containment pressure of 43.0 psig results from the SLB analysis and is calculated to be less than the containment design pressure. The maximum 309°F peak containment atmosphere temperature results from the SLB analysis and is calculated to exceed the containment design temperature for a relatively short period of time during the transient. The basis of the containment design temperature, however, is to ensure OPERABILITY of safety related equipment inside containment (Ref. 2). Thermal analyses show that the time interval during which the containment atmosphere temperature exceeds the containment design temperature is short enough that there would be no adverse effect on equipment inside containment. Therefore, it is concluded that the calculated transient containment atmosphere temperatures are acceptable for the SLB and LOCA.

The RS System actuation model from the containment analysis is based upon a response associated with exceeding the Containment Pressure—High High signal setpoint and RWST level decreasing below the RWST Level—Low setpoint. The containment analysis models account conservatively for instrument uncertainty for the Containment Pressure—High High setpoint and the RWST Level—Low setpoint. The RS System's total response time is determined by the time to satisfy the coincidence logic, the timer delay for the inside RS pumps, pump startup time, and piping fill time.

For certain aspects of accident analyses, maximizing the calculated containment pressure is not conservative. In particular, the cooling effectiveness of the Emergency Core Cooling System during the core reflood phase of a LOCA analysis increases with increasing containment backpressure. For these calculations, the containment backpressure is calculated in a manner designed to conservatively minimize, rather than maximize, the calculated transient containment pressures in accordance with 10 CFR 50, Appendix K (Ref. 3).

The radiological consequences analysis demonstrates acceptable results provided the containment pressure decreases to 2.0 psig in 1 hour and does not exceed 2.0 psig for the interval from 1 to 6 hours following the Design Basis

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

Accident (Ref. 4). Beyond 6 hours the containment pressure is assumed to be less than 0.0 psig, terminating leakage from containment.

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

LCO

During a DBA, one train (one inside and one outside RS subsystem in the same train) or two outside RS subsystems of the RS System are required to provide the minimum heat removal capability assumed in the safety analysis. To ensure that this requirement is met, four RS subsystems and the casing cooling tank must be OPERABLE. This will ensure that at least one train will operate assuming the worst case single failure occurs, which is no offsite power and the loss of one emergency diesel generator. Inoperability of the casing cooling tank, the casing cooling pumps, the casing cooling valves, piping, instrumentation, or controls, or of the QS System requires an assessment of the effect on RS subsystem OPERABILITY.

Each RS train consists of one RS subsystem outside containment and one RS subsystem inside containment. Each RS subsystem includes one spray pump, one spray cooler, one 180° coverage spray header, nozzles, valves, piping, instrumentation, and controls to ensure an OPERABLE flow path capable of taking suction from the containment sump.

APPLICABILITY

In MODES 1, 2, 3, and 4, a DBA could cause an increase in containment pressure and temperature requiring the operation of the RS System.

In MODES 5 and 6, the probability and consequences of these events are reduced due to the pressure and temperature limitations of these MODES. Thus, the RS System is not required to be OPERABLE in MODE 5 or 6.

ACTIONS

A.1

With one of the RS subsystems inoperable, the inoperable subsystem must be restored to OPERABLE status within 7 days. The components in this degraded condition are capable of providing at least 100% of the heat removal needs (i.e., approximately 150% when one RS subsystem is inoperable)

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BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.6.7.6

These SRs ensure that each automatic valve actuates and that the casing cooling pumps start upon receipt of an actual or simulated High-High containment pressure signal. The RS pumps are verified to start with an actual or simulated RWST Level—Low signal coincident with a Containment Pressure—High High signal. The start delay times for the inside RS pumps are also verified. This Surveillance is not required for valves that are locked, sealed, or otherwise secured in the required position under administrative controls. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the Surveillance when performed at the 18 month Frequency. Therefore, the Frequency was considered to be acceptable from a reliability standpoint.

SR 3.6.7.7

Periodic inspections of the containment sump components ensure that they are unrestricted and stay in proper operating condition. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a unit outage and on the need to have access to the location. This Frequency has been found to be sufficient to detect abnormal degradation and is confirmed by operating experience.

SR 3.6.7.8

This SR ensures that each spray nozzle is unobstructed and that spray coverage of the containment will meet its design bases objective. Either an inspection of the nozzles or an air or smoke test is performed through each spray header. Due to the passive design of the spray header and its normally dry state, a test performed following maintenance which could result in nozzle blockage is considered adequate for detecting obstruction of the nozzles.

REFERENCES

1. UFSAR, Section 6.2.
2. 10 CFR 50.49.
3. 10 CFR 50, Appendix K.

BASES

REFERENCES (continued)

4. UFSAR, Section 15.4.1.7.
5. ASME Code for Operation and Maintenance of Nuclear Power Plants.