Enclosure 2
Westinghouse APP-GW-GLR-607, Revision 4
(NON-PROPRIETARY VERSION)

(102 pages including cover page)

Open Items

This document has no open items.

Record of Revisions

Revision	Changes
0	Initial issue.
1	Added detail to discussion of how the change meets the ISG-11 criterion in response to NRC and APOG comments. Changed description of downspout symmetry. Relocated containment peak pressure response discussion to Chapter 6 heading to coincide with its place in the DCD. Clarified justification for why containment peak pressure response is not impacted. Added details to discussion for why Chapter 15 is not affected. Added text to describe Chapter 19 changes. Clarified description of compliance the GDCs and with 10 CFR 50.46 and 10 CFR 50, Appendix K. Clarified use of the words "DCD," "FSAR," "plant-specific DCD" and "licensing basis" throughout the document. Clarified status of proposed changes in the significant hazards determination and added further justification. Change "PXS gutter" to "IRWST gutter" to align with the terminology used in the licensing basis ("PXS gutter" is not used in the DCD or CLB). Addressed customer comments.
2	This revision updates the Condensate Return submittal to include the recent changes to the condensate return evaluation, including: - Updates to the Licensing Basis markups based on DCP APP-GW-GEE-5007. - Updates to descriptions of the supporting calculations based on changes in the condensate return calculation process. - Minor editorial changes
3	This revision updates the Condensate Return submittal to include the following changes: - The complete set of FSAR/DCD markups is included in Appendix B. - Minor editorial changes, highlighted with track changes.
4	This revision updates the Condensate Return submittal to include the following changes: - Additional description of the long term cooling case (72 hours – 14 days), - Licensing basis markup clarifications – Appendix B. - Editorial changes, highlighted with track changes.

Changes to Passive Core Cooling System Condensate Return

Originator: Jennifer E. Meneely
U.S Regulatory Support

Reviewer: Andrew F. Pfister
AP1000 Plant and Analysis Integration

Verifier : Fletcher T. Wilkins
New Plant Licensing

Manager: James F. Mermigos
U.S. Licensing Change Programs

January 2016

Changes to Passive Core Cooling System Condensate Return

Table of Contents

1.0 Introduction

According to the **AP1000®** Design Control Document Revision 19 (Reference 3), subsection 6.3.1.1.1, "Emergency Core Decay Heat Removal," among the safety-related design bases of the Passive Core Cooling System (PXS) is the capability for the Passive Residual Heat Removal Heat Exchanger (PRHR HX) to cool the Reactor Coolant System (RCS) to the safe shutdown condition of 420°F in 36 hours. The Nuclear Regulatory Commission Staff recommended, in SECY-94-084 (Reference 1), that reactor designs utilizing passive safety systems include a residual heat removal system capable of bringing the reactor to a safe shutdown condition of 420°F (215.6°C) or lower within 36 hours following non-loss of coolant accident (LOCA) events. To support the capability of the **AP1000** design to meet these safe shutdown conditions, a safe shutdown temperature evaluation was performed, which assumed a condensate return fraction for the PXS.

Through a series of design reviews, the efficiency of the condensate return to the In-Containment Refueling Water Storage Tank (IRWST) was questioned. These questions initiated an investigation to quantify the returned fraction of condensate to the IRWST. Supplementary testing of the **AP1000** design revealed opportunities to improve the design with regard to the condensate return fraction used to evaluate long-term plant cooldown. In addition, a rigorous analysis methodology was applied to characterize both the thermodynamic and the geometric phenomena involved in prolonged non-LOCA events. The Shutdown Temperature Evaluation in Chapter 19E of the **AP1000** Design Control Document (DCD) has been updated to analyze the PRHR HX performance with the design modifications to confirm it meets its licensing performance criterion of cooling the RCS to 420°F within 36 hours and maintaining a safe, stable condition. In addition, an extended design basis accident evaluation is performed out to 72 hours that shows compliance with the Chapter 15 non-LOCA acceptance criteria. These changes were evaluated against the NRC Interim Staff Guidance DC/COL-011; and were determined to meet the criteria for a change that should not be deferred while a license application is under review.

This report discusses expected PRHR HX operation, condensate loss mechanisms, condensate return test results and the design modifications made to enhance performance of the PXS. Most importantly, changes to the licensing basis supporting these modifications to the PXS are detailed and compliance to NRC regulations evaluated.

2.0 Background

Regulatory Basis

NRC regulations require that the **AP1000** design include a system to remove residual heat from the reactor core so that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded (Reference 2). PXS provides emergency core cooling during transients, accidents, and whenever the normal, nonsafety-related heat removal paths are unavailable. The PXS is capable of bringing the plant to and maintaining the plant in a safe, stable condition following shutdown.

Operation

The PRHR HX is safety-related and provides emergency core decay heat removal. It is located in the IRWST as shown on Tier 2 DCD Figure 6.3-2. The heat exchanger is used in non-LOCA transients and also in LOCA events until voiding begins in the RCS Hot Leg. For any non-LOCA event, the PRHR HX plays an integral role in decay heat removal, as opening one of the two outlet isolation valves initiates natural circulation of the heat exchanger, transferring heat from the RCS into the IRWST. This transfer of heat from the RCS to the IRWST causes the water in the tank to heat up, eventually become saturated, and initiate steaming of the tank.

The steam generated will discharge through a series of vents located near the steam generator compartments at the roof of the IRWST. The steam generator wall vents open with a slight pressure differential between the IRWST and containment, providing a path to vent steam produced by the PRHR HX into the containment atmosphere. The steam generator wall vents open at a lower differential pressure than the IRWST hood vents located near the containment wall, which ensures the steam generator wall vents will open first. The location of the steam generator wall vents (near the center of containment) contributes to mixing of the containment atmosphere. The steam released from the IRWST condenses on "passive heat sinks" within the containment, such as the containment vessel wall, Polar Crane Girder (PCG), concrete, piping, components, or any other subcooled surface until these passive heat sinks reach saturation temperature. Condensation on the inside of the containment vessel wall forms a thin fluid film and runs down the containment wall surface. Provisions are made to collect and channel condensate to the IRWST.

The PCG and internal hoop stiffener (internal stiffener) are horizontal, circumferential attachments to the containment sidewalls that interrupt condensate flow. The PCG and internal stiffener increase the radial and rotational stiffness of the containment vessel, and are designed to allow condensate to drain back to the IRWST gutter. The PCG also supports the polar crane.

The PCG is a box girder consisting of 80 enclosed boxes; and is shown in Tier 2 DCD Figure 3.8.2-1 (Sheet 3 of 3). The front face of each box (facing into containment) has a 2 foot diameter opening. The rear face of each box is the containment wall. The PCG is constructed with chamfers and fabrication holes to allow condensate to drain past the PCG to the internal stiffener. The internal stiffener is an angle stiffener and also contains fabrication holes to allow condensate to drain past it to the IRWST gutter.

Condensate is collected in the IRWST gutter, which extends around the circumference of containment and returns condensate to the IRWST.

Upon actuation of the PRHR HX, two air-operated valves in series are actuated to isolate the normal gutter drain path to the Liquid Radwaste System, and divert condensate to the IRWST. It is important that sufficient condensate return is achieved during non-LOCA PRHR HX operation. The ability to maintain closed-loop PRHR HX cooling for long periods minimizes the probability that open-loop cooling will be needed. Although maintaining IRWST level above the top of the HX tubes is not a prerequisite for maintaining adequate decay heat removal, reduction of IRWST level to below the top of the tubes will begin to degrade the heat exchanger performance.

<u>Analyses</u>

The **AP1000** Design Control Document (DCD) Revision 19 Chapter 19E Safe Shutdown temperature evaluation analysis assumes a constant portion of steam discharged to the containment is returned back to the IRWST. However, there was not a strong basis justifying the efficiency of the PXS condensate return function. Therefore, the decision was made to conduct testing and to characterize condensate return with calculations that included quantification of steaming from the IRWST and the portion of that steam that condenses and returns to the IRWST.

Testing results showed the current design of the PCG, internal stiffener, and IRWST gutter contributed to losses at each location, which were larger than assumed. In addition to the losses due to the physical geometry of containment, there were also losses due to pressurization and heat-up of containment structures. These losses proved that the constant condensate return fraction assumed in the safety analyses was incorrect. Analytically, when the constant condensate return assumption was replaced with the experimental design return rates including losses, the resultant PRHR HX performance was degraded and could have affected the temperature profiles and the event times of the non-LOCA design basis accident (DBA) safety analyses described in Chapter 15 of the DCD if left uncorrected. The PCG and internal stiffener can be modified to improve condensate return such that the Chapter 15 design basis analyses would not be impacted.

The Safe Shutdown temperature evaluation is an analysis that extends beyond the end of the analyses described in Chapter 15 of the DCD. Therefore, to provide long term confirmation of acceptability with regard to the Chapter 15 non-LOCA acceptance criteria, it is deemed appropriate to consider an extended design basis accident evaluation out to 72 hours.

3.0 Discussion

Condensation

As steaming to the containment begins following PRHR HX operation and saturation of the IRWST, there are a number of mechanisms, both thermodynamic and geometric, that can prevent the condensed steam from returning to the IRWST. The mechanisms are as follows:

1) Steam to pressurize the containment
2) Steam condensation on passive heat sinks
3) Raining from the containment roof, Containment ring misalignment
4) Losses at the PCG and Stiffener
5) Losses at support plates attached to the containment vessel
6) Losses at the Equipment Hatch and Personnel Airlock
7) Losses at entry to IRWST Gutter

Condensation losses were evaluated by calculations and prototype testing. The losses due to pressurization, raining and condensation on passive heat sinks were quantified with a revision to existing calculations.

A full scale section of the containment wall was constructed at the Westinghouse Waltz Mill facility [ ][a,c].
The testing at Waltz Mill is discussed in Section 4.0.

The locations of the Polar Crane Girder, internal stiffener, and IRWST gutter are illustrated in Figure 1.

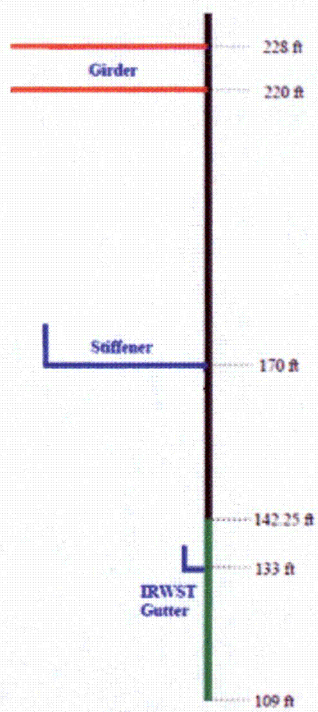

Figure 1: Example Containment Wall Schematic

4.0 Testing

A full scale section of the containment vessel (CV) wall, 55 feet tall, was constructed at the Westinghouse Waltz Mill Facility to accurately test and quantify the various loss mechanisms along the length of the containment wall. [

.] (a,c)

a,b,c

.]a,b,c

.]a,b,c

]a,b,c

.] (a,c)

Test Observations and Insights

Testing of the aforementioned configurations determined that a number of design optimizations were available to improve the performance of the condensate return system. Modifications were made at the half circle fabrication hole locations at the PCG and stiffener. A downspout piping system was deemed to be the most effective option for optimizing condensate return. The specific modifications needed at the PCG and stiffener are highlighted in Section 5.0.

.] (a,c)

[

]a,b,c

The details related to the condensate return testing conducted at Waltz Mill are available for inspection by the NRC.

5.0 Design Changes

As a result of the condensate return testing conducted at the Waltz Mill Test Facility, modifications to the PCG, internal stiffener, and IRWST gutter design were made. In addition, extensions of the gutter were added above the Upper Personnel Airlock and Upper Equipment Hatch. A downspout system was also added to capture condensation at the PCG and stiffener locations. Each of these items is discussed in detail on the following pages.

<u>Polar Crane Girder and Internal Stiffener Modifications</u>

1) PXS Downspout Piping

A downspout piping network would be added to collect and transport condensation from the PCG and stiffener to the IRWST gutter collection boxes. The downspouts would consist of two downspout branches, each with two connections to the top of the PCG, two connections to the bottom of the PCG and two connections to the internal stiffener. Figure 3 illustrates the two downspout branches incorporated into the PXS system design. In each branch, the four connections from the PCG would join together into a common header which extends below the internal stiffener. The two connections from the stiffener would join together into a common line, which would connect to the header below the stiffener. The header would be routed to one of the two PXS collection boxes at either side of the IRWST. The downspouts would be situated with approximate symmetry around the circumference of containment. The common header for each branch would pass through the internal stiffener. These pass-through locations would include penetration sleeves to allow sufficient depth for collection at the stiffener downspout inlets.

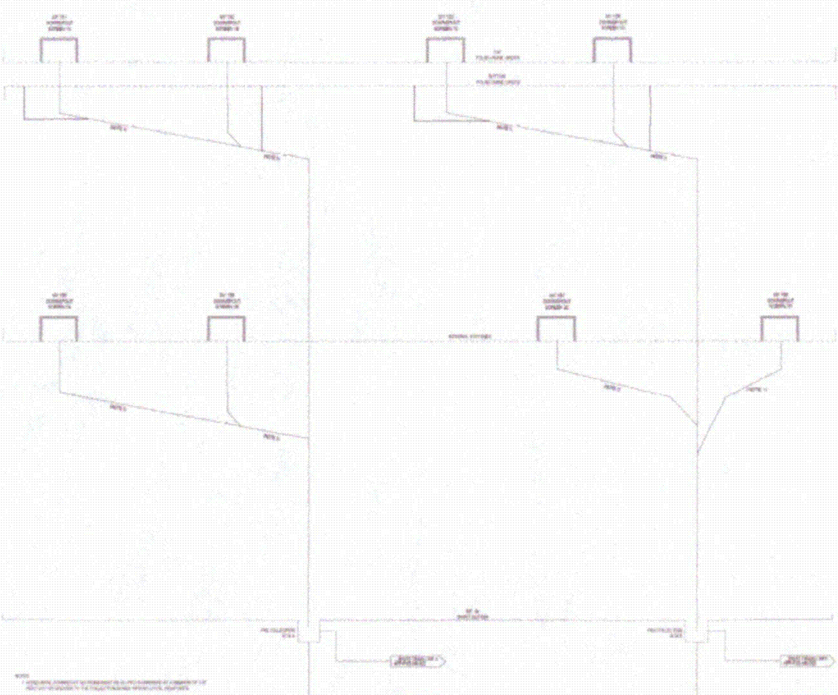

Figure 3: Simplified Downspout Configuration

The PCG boxes would be modified to allow condensate to drain from inside the PCG. The configuration of the collection boxes is modified to accommodate the additional downspouts. The piping is constructed of materials approved for use inside containment, consistent with DCD Tier 2, Section 6.1.1.4 (Reference 3). The downspouts will have tag numbers PXS-L301A/B to PXS-L310A/B. The downspouts are **AP1000** Safety Class C, Seismic Category I.

Pipe sizes were selected to prevent pipes from running full of water. The pipe sizes were also selected to accommodate a single failure (blockage) of one of the screens over the inlet to the downspouts. [

](a,c) All sections of piping routed horizontally are sloped 1/8 inch per foot or greater downward toward each of the respective collection boxes. The PXS piping and instrumentation diagrams were changed accordingly.

2) Downspout Screen Design

The original IRWST gutter design includes an expanded metal flat screen which is fastened over the entrance to the gutter. The primary focus of the metal screen was to prevent larger debris from entering the gutter and potentially interfering with flow into the gutter or piping from the PXS collection boxes. Similarly, at the entrance of each of the downspouts from the top of the PCG and from the stiffener, a screen is needed for the same function – to prevent any larger debris from blocking the downspout piping. The screens are designed to allow small debris to pass through.

Eight (8) new PXS downspout screens were added. The screens will have the tag numbers PXS-MY-Y81 to PXS-MY-Y88. The screen at each downspout entrance is **AP1000** Safety Class C, Seismic Category I.

.](a,c)

Figure 4 provides an illustration of a downspout screen.

a,c

The screens would be constructed of materials compatible with the post-accident environment, consistent with DCD Tier 2 subsection 6.1.1.4. Aluminum would not be used for these components. The screen would be designed to allow small debris to pass through; and provide sufficient flow area to accommodate design basis flow rates at the PCG and internal stiffener locations. [

.] (a,c)

3) Blocking of PCG/Stiffener Fabrication Holes

The PCG is made up of sections, which are welded together around the circumference of containment. At each interface where the top and bottom plate sections are welded together, all four corners have openings to prevent multiple welds from joining at a common location. Therefore, the assembled PCG has open fabrication holes at the corners where the sections interface. The stiffener is similarly assembled in sections and contains fabrication holes at the interface where each section is welded together. DCD Tier 2 Figure 3.8.2-1 (Sheet 3 of 3) shows an example of the fabrication holes. The fabrication holes in the PCG and in the stiffener would be blocked.

4) Addition of Dam on the PCG

]a,c a dam is welded to the top of the PCG between the CV wall and the crane rail and to the bottom front edge of the PCG. [

.]a,c The proposed top side dam is depicted in Figure 5.

[ ]a,c

[

.] (a,c)

a,c

Personnel Airlock and Equipment Hatch Gutter Routing

The original IRWST gutter was routed to the edges of the Upper Personnel Airlock and Upper Equipment hatch. [ ] (a,c) The IRWST gutter will be modified to have an upper gutter above each of the hatches that connects with the existing gutter. The extended gutter is of the same size as the sections which currently interface with the sides of the hatches. The gutter is sloped the same as the existing portions of the gutter. The extended portion of the gutter above the Upper Personnel Airlock is routed to interface with the lower portion of the gutter. Figure 8 shows a schematic of the proposed modification to the IRWST gutter to above the Upper Personnel Airlock. The Upper Equipment Hatch is similarly treated.

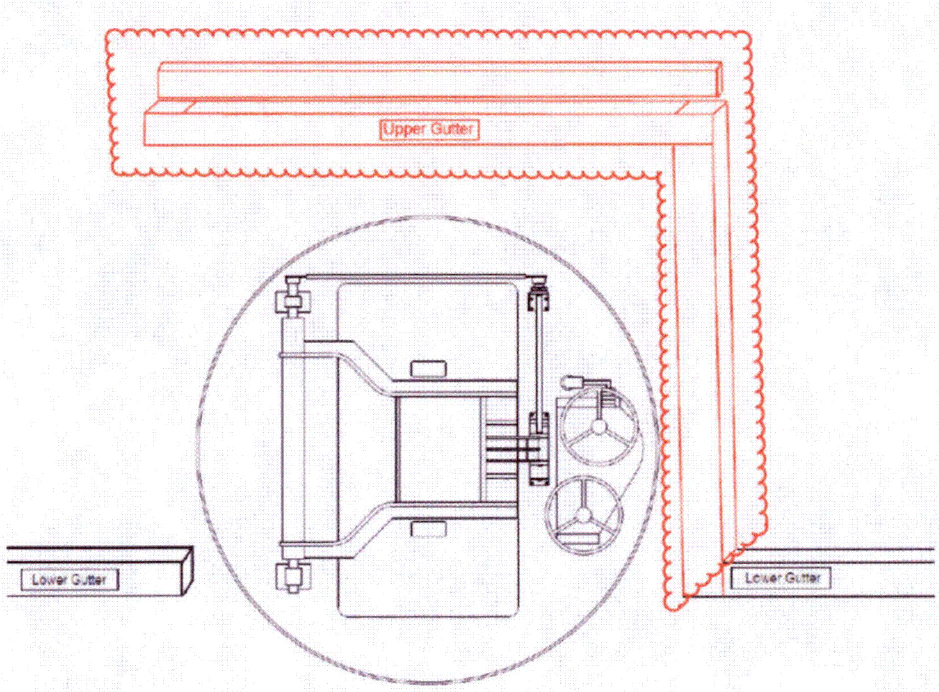

Figure 8: Personnel Airlock Gutter Modification Schematic

The Shutdown Temperature Evaluation summarized in DCD subsection 19E.4.10.2 was updated (Reference 7). The analysis is performed using the LOFTRAN computer code, as before, with a more detailed input for the condensate return fraction. Condensate return is affected by the containment pressure, which determines the PRHR HX heat sink (IRWST water) temperature. The WGOTHIC containment model described in DCD subsection 6.2.1.1.3 was used to model the peak containment pressure, with limited changes made to the model to maximize condensate losses (as opposed to maximizing peak pressure). The WGOTHIC model was used to calculate thermodynamic condensate losses due to containment pressurization, containment leakage and passive heat sink saturation (Reference 8). A bounding condensate loss from the containment shell (confirmed by Reference 9, which incorporates the changes described in section 5.0) is used as input to the WGOTHIC model, which in turn outputs a condensate return flow and a IRWST steaming rate. Subsequently, these two outputs are combined to develop a time dependent condensate return fraction, which is input to the downstream LOFTRAN calculation.

Reference 7 confirms that sufficient condensate is returned to the IRWST to maintain the IRWST water level above the top of the PRHR HX tubes meeting the success criteria of the design basis non-LOCA events described in DCD Chapter 15, even when extended out to 72 hours. The time-dependent condensate return fraction was input into the LOFTRAN code to demonstrate the ability of the PRHR HX to cool the RCS temperature to 420°F within 36 hours in a closed-loop mode of operation. This analysis demonstrated that the proposed changes to channel condensate that reaches the PCG and internal stiffener back to the IRWST maintains sufficient IRWST inventory. The analysis shows the plant can successfully meet this licensing performance criterion using conservative, non-bounding methods (Reference 7). A description of the differences and conservatisms applied in these analyses is presented in Appendix A.

Based on the updates to the safe shutdown evaluation, the supporting licensing basis tables and figures need to be updated to reflect the current design. Section 19E.4.10.2, Table 19E.4.10-1, and the supporting figures, Figure 19E.4.10-1, -2, -3, and -4 will be updated by this change package.

6.0 Impacts to the Licensing Basis

Condensate return to the IRWST is discussed widely throughout DCD Revision 19 in conjunction with PRHR HX operation. Though the changes described in Section 5.0 do not change the condensate return concept or the safe shutdown temperature analysis methodology, the licensing basis changes proposed herein provide additional piping, components and adjustments to optimize the descriptions of the condensate return provisions and provide descriptions of the analysis methodology in the plant-specific DCD.

<u>Tier 1</u>

The added components of the PXS are integral to providing safety-related core decay heat removal during non-LOCA events. Therefore, it is appropriate to apply inspections, tests, analyses and acceptance criteria to the added PXS components to provide reasonable assurance that the facility has been constructed and will be operated in conformity with the applicable design criteria, codes and standards.

The downspout screens would support the capability of the PRHR HX to maintain the reactor in a safe shutdown condition by preventing large objects from entering the downspout piping. As required by General Design Criterion 2 of Appendix A to 10 CFR Part 50, the PXS is designed to withstand the effects of natural phenomena and normal and accident conditions without loss of capability to perform its safety functions. The PXS downspout screens would be safety-related, located on the Nuclear Island; and required to withstand design basis seismic and post-accident operating loads without losing the capability to perform their safety function. The component numbers for the following downspout screens are added to Table 2.2.3-1 to provide assurance that ITAAC design commitments will be met. The resultant change to Tier 1 is shown in Appendix B.

PXS-MY-Y81	PXS-MY-Y85
PXS-MY-Y82	PXS-MY-Y86
PXS-MY-Y83	PXS-MY-Y87
PXS-MY-Y84	PXS-MY-Y88

The downspout piping would support the capability of the PRHR HX to maintain the reactor in a safe shutdown condition by inhibiting containment floodup during PRHR HX operation and delaying the need for containment recirculation following RCS depressurization. As required by general design criterion 4 of Appendix A to 10 CFR Part 50, the PXS containment downspout piping would be safety-related and required to withstand normal and seismic design basis loads without losing functional capability. The additional downspout piping added to the PXS is captured in Table 2.2.3-2 to provide assurance that ITAAC design commitments will be met. The resultant change to Tier 1 is shown in Appendix B.

PXS-L301A	PXS-L306A	PXS-L301B	PXS-L306B
PXS-L302A	PXS-L307A	PXS-L302B	PXS-L307B
PXS-L303A	PXS-L308A	PXS-L303B	PXS-L308B

PXS-L304A	PXS-L309A	PXS-L304B	PXS-L309B
PXS-L305A	PXS-L310A	PXS-L305B	PXS-L310B

General design criteria 34 and 35 require that the PXS be capable of removing core decay and residual heat and provide an abundance of core cooling such that fuel design limits and the RCS design conditions are not exceeded. As the PXS provides core decay heat removal during design basis events, performance of this safety-related function is confirmed through ITAAC design commitment 8.b. The changes described herein do not change the commitment to complete the performance test of the PRHR HX. No further changes to Tier 1 are required to assure the desired PXS performance is confirmed in this performance test.

Tier 2

Chapter 1: Impacted

The **AP1000** design response for Question A-31 (Residual Heat Removal Requirements) was updated to provide consistent language with other portions of the design control document that discuss the condensate return scenario. Additional pointers were also added to the appropriate sections where events are discussed in further detail.

Subsection 1.9.5.1.5 "Station Blackout" was updated to keep the language consistent with other areas of the design control document.

Chapter 3: Impacted

The new PXS downspout screens are **AP1000** Safety Class C and Seismic Category I components. These components meet the quality assurance requirements of 10 CFR 50, Appendix B. Additionally, the screens must be demonstrated to have no functional damage following a seismic ground motion exceeding the one-third of the safe shutdown earthquake ground motion before resuming operations in accordance with 10 CFR Part 50, Appendix S. The screens added to Tier 1 Table 2.2.3-1 are also added to Table 3.2-3 to capture these requirements. The markup to Table 3.2-3 is shown in Appendix B.

Pictorial detail of the PCG is shown in DCD Chapter 3. Figure 3.8.2-1 (Sheet 3 of 3) shows the fabrication holes in the top right figure. As the fabrication holes in the PCG would be blocked in the modified configuration, this detail will be removed from this figure. The changes are shown in Appendix B.

Chapter 5: Impacted

In subsection 5.4.11.2, cross reference to Figure 6.3-2 is changed to Figure 6.3-1 for consistency across the chapters.

Changes were also made to subsection 5.4.14.1 to add discussion about the design bases of the PRHR HX.

These changes are shown in Appendix B, note that this portion of the markups was originally made by References 10 and 11.

Chapter 6: Impacted

To reflect the changes to the PXS system, the additional downspout piping is captured in the gutter discussions of UFSAR subsection 6.3 and on a new sheet of the PXS piping and instrumentation diagrams (P&IDs). In order to add the new P&ID sheet to the licensing basis, Figure 6.3-1 will be expanded to include all sheets of the PXS P&IDs and Figure 6.3-2 will not be used.

- Subsection 6.3.1.1.1 will be updated to describe the downspouts in the safety-related design criteria and provide clarification regarding the safety related design basis of the PRHR HX during closed-loop passive core cooling.
- Subsection 6.3.1.1.4 will be updated to provide discussion about the safety related cooldown capabilities of the PRHR HX. Additional discussion has also been added regarding operator action to block ADS if the RCS is in a safe, stable condition.
- Section 6.3.1.2 was added to discuss the nonsafety design basis of the PRHR HX.
- The original section 6.3.1.2 was renumbered as section 6.3.1.3.
- Subsection 6.3.2.1.1 will be updated to include the intermediate collection points of the safety-related gutter arrangement and additional discussion about the operation of the condensate return features of passive core cooling system.
- Subsection 6.3.2.2.5 will be updated to remove the discussion about water relief through the pressurizer safety valves.
- Subsections 6.3.2.2.7 and 6.3.2.2.7.1 will be updated to clarify the number of screen sets in the PXS and to which set of screens the criteria in this section apply.
- Subsection 6.3.2.2.7.2 will be updated to clarify the condensate return gutter arrangement related to LOCA operation.
- Section 6.3.2.8 will be updated to add discussion regarding the manual actions that can be taken by the operator to block ADS if the RCS is in a safe, stable condition.
- Section 6.3.3 will be updated to provide additional information regarding the operation of the PRHR HX.
- Subsection 6.3.3.2.1.1 "Loss of AC Power to the Plant Auxiliaries" will be added to describe how the plant will respond during a loss of ac power combined with a loss of main feedwater event.
- Subsection 6.3.3.4.1 will be updated to remove the term "indefinitely" from the length of time the heat sinks need to function.
- Figure 6.3-1 will be relabeled Figure 6.3-1 (Sheet 1 of 3). This editorial change is the only change made to this figure. No technical changes are made.
- Figure 6.3-2 will be relabeled Figure 6.3-1 (Sheet 2 of 3). On relabeled Sheet 2, the IRWST gutter has been relocated to a new sheet 3 of the PXS P&IDs. Sheet 2 has been modified to include continuation flags for condensate returning to the IRWST originating from PXS Collection Boxes A and B in the IRWST gutter.
- Figure 6.3-1 (Sheet 3 of 3) is a new P&ID sheet and will be added to the licensing basis. This new figure shows the relocated IRWST gutter and the screens and piping comprising the PXS downspouts originating from the Polar Crane Girder and internal stiffener.
- Figure 6.3-2 will not be used.
- The Chapter 6 List of Figures will be updated to reflect the PXS figure relabeling and the additional PXS P&ID sheet.
- Reference to Figure 6.3-2 in subsection 6.3.2.1 is changed for consistency.

The changes Chapter 6 are shown in Appendix B. Note that some of these markups were originally made by References 10 and 11.

The WGOTHIC peak containment pressure analysis was considered during the course of testing and analysis for this change; and was determined not to be affected by this change for the following reasons. With regard to peak containment pressure, the limiting design basis event is a double-ended guillotine cold leg break (DECLG) LOCA. The containment peak pressure for the DECLG LOCA case is not sensitive to the time-dependent condensate return, as the peak pressure is reached well before condensate return plays a factor in the event. Additionally, in the later stages of the transient (24 and 72 hours) the beneficial effects of condensate return are not considered in the containment peak pressure and temperature analysis. The current WGOTHIC containment response model assumes condensate that reaches the polar crane girder and internal stiffener is deposited in the containment sump and no longer contributes to the film thickness at lower elevations of the containment wall. Therefore, the containment analysis methodology remains bounding and is consistent with the modified design as described in Section 5.0.

Chapter 7: Impacted

The changes that will be made to section 7.4 and 7.4.1.1 are shown in Appendix B and are considered clarifications to the original words about safe shutdown. The changes that will be made to subsection 7.4.1.1 are additions to describe the operation of the PRHR HX during a design basis event. Note that the 7.4.1.1 markups were originally made by References 10 and 11.

Chapter 9: Impacted

Table 9.5.1-1 will be updated to add clarifications about the safe shutdown operation of the AP1000 plant. The changes to Chapter 9 are shown in Appendix B, note that this portion of the markups was originally made by References 10 and 11.

Chapter 14: Impacted

In Table 14.3-2, cross reference to Figure 6.3-2 will be changed to Figure 6.3-1 for consistency across the chapters. The changes to Chapter 14 are shown in Appendix B.

Chapter 15: Impacted

Chapter 15 design basis transients that credit PRHR HX operation, along with the analysis run time are listed in Table 1. In these analyses, a constant condensate return fraction was used for the safety analysis models supporting Chapter 15. However, though the condensate return fraction has changed, the transient analyses in Chapter 15 bound the plant response expected as a result of the proposed design changes. During the transients which credit PRHR HX operation, there is no impact to the heat transfer rate of the heat exchanger until the point that the water level in the IRWST drops below the top of the tube sheet, reducing the available heat transfer area. For the transient analyses in Chapter 15, the response will not change because even if the time-dependent condensate return fraction were applied, the PRHR HX would remain submerged well beyond the duration of the relevant design basis analyses listed in Table 1. In order to demonstrate that there is no impact to Chapter 15, an extended 72 hour case of the limiting event was completed (Appendix D of Reference 7). The analysis shows all Chapter 15 acceptance criteria are met through the duration of the analysis. To add additional conservatism to the WGOTHIC calculated variable condensate return fraction, the analysis assumes a 5% reduction throughout the transient.

Table 1

DCD Chapter 15 Design Basis Accidents Crediting PRHR HX Operation

DCD subsection	Transient Name	Run Time
15.2.2	Loss of external electrical load(1)	(2)
15.2.3	Turbine trip(1)	<1 minute
15.2.6	Loss of ac power to the plant auxiliaries	<6.2 hours
15.2.7	Loss of normal feedwater flow	<5.5 hours
15.2.8	Feedwater system pipe break	<3.2 hours
15.5.1	Inadvertent operation of the core makeup tanks during power operation	<8.6 hours
15.5.2	Chemical and volume control system malfunction that increases reactor coolant inventory	<5.7 hours
15.6.3	Steam generator tube rupture	<6.7 hours

1. PRHR HX is not specifically credited in this analysis; but could be relied upon in the long term to support recovery.
2. This transient is bounded by the turbine trip event.

While the discussion above demonstrates the changes to the gutter systems and condensate return features of the PXS do not impact the licensing basis, minor changes were made to the surrounding Chapter 15 text. These changes are shown in the markups in Appendix B, note that this portion of the markups was originally made by References 10 and 11.

- Section 15.0.13 will be updated to provide the safe, stable shutdown mission time of the PRHR HX and make a minor editorial change
- Subsection 15.2 will be updated to provide additional clarification regarding the measurement of performance of the PHRH HX during design basis events.
- Subsection 15.2.6.1 will be updated to add description to the operation of the PRHR HX.

Chapter 16: Impacted

The Technical Specification Bases will be updated to include the downspouts in the descriptions of the gutter arrangement.

- The Bases LCO for B 3.3.3 will be updated to reflect the addition of downspouts.
- The Technical Specification Surveillance Requirement and the Bases Surveillance Requirement for SR 3.5.4.7 will be updated to encompass the entire gutter arrangement, including the downspout screens, in the surveillance.

- The Bases Background for B 3.5.4 will be updated to reflect the addition of downspouts.

The changes to Chapter 16 are shown in Appendix B.

Chapter 19: Impacted

Two portions of Chapter 19 were impacted. Table 19.59-18, will be updated to add clarification about the PRHR HX. This markup is shown in Appendix B. Note that this portion of the markups was originally made by References 10 and 11.

The second portion is in Chapter 19E. Per SECY-94-084, the NRC recommends the requirement of 420°F or below as a safe, stable shutdown condition. An overall discussion of safe shutdown for AP1000 are represented in DCD subsection 19E.2.3.2.6 and the results of the shutdown temperature evaluation are represented in DCD Revision 19 subsection 19E.4.10.2, Table 19E.4.10-1 and Figures 19E.4.10-1 through 19E.4.10-4.

The discussion regarding safe shutdown for AP1000 are found in subsection 19E.2.3.2.6. This discussion will be expanded to fully detail the safety-related functional requirements of the PRHR HX during non-LOCA events. Some additional discussion has also been added regarding operator action to block ADS if the RCS is in a safe, stable condition.

The results of safe shutdown temperature evaluation are found in subsection 19E.4.10.2, The original evaluation was performed at best estimate conditions, with a number of conservatisms maintained, and assumed a constant condensate return rate. The plant response after shutdown following non-LOCA events was reanalyzed with a series of interdependent calculations, made using non-bounding, conservative assumptions. The updated information flow between these calculations is illustrated in Figure 9.

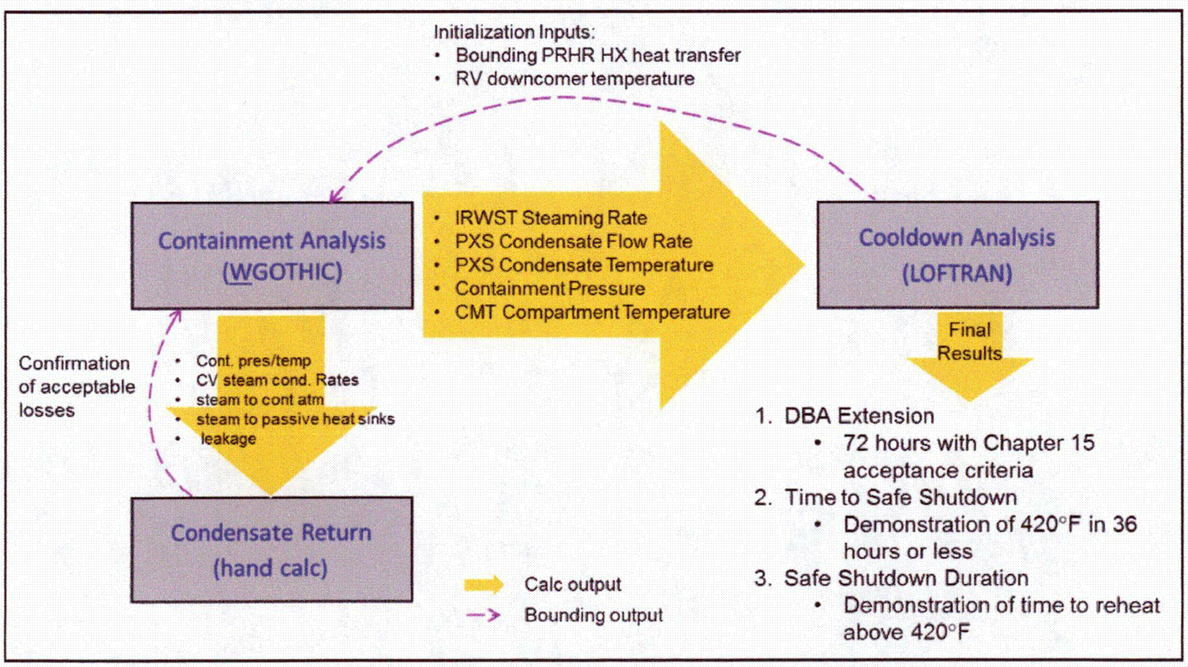

Figure 9: Calculation inter-relationships

The design changes described in Section 5.0 ensure sufficient condensate is returned to the

IRWST to preserve PRHR HX performance after shutdown following a non-LOCA event. To verify the effectiveness of the proposed changes to the PXS system, several analyses (discussed in Appendix A) were performed, which incorporate the lessons learned about condensate return from design review and testing. As described in subsection 4.2 of the Shutdown Temperature Evaluation (Reference 7), loss of normal feedwater coincident with loss of ac power event was identified to be the most limiting transient with regard to PRHR HX performance. The Shutdown Temperature Evaluation is performed to demonstrate the adequacy of the PRHR HX to reduce the core average temperature to 420°F within 36 hours after shutdown following a loss of normal feedwater coincident with loss of ac power event. The containment peak pressure and temperature design limits are not challenged by the long-term loss of normal feedwater with loss of ac power event that forms the limiting basis for the safe shutdown temperature evaluation, as the maximum pressure reached during the loss of normal feedwater coincident with loss of ac power event does not approach the containment design pressure.

Following a loss of ac power event, reactor coolant system energy is slowly transferred to the IRWST following actuation of the PRHR HX. The water in the IRWST will begin to heat up, eventually coming to a boil. The steam released by boiling of the IRWST will cause the containment temperature and pressure to increase. To evaluate the containment response to IRWST steaming and time-dependent condensate return on PRHR HX performance, minor modifications were made to the approved WGOTHIC containment response model to increase condensation and produce conservative results. The Containment Analysis (APP-PXS-M3C-071, Reference 8) performed with the WGOTHIC model calculates several key inputs to both the Condensate Return calculation (Reference 9) and the Safe Shutdown Temperature Evaluation (Reference 7). The Containment Analysis provides the containment pressure and temperature, containment vessel steam condensate rates, steam to the containment atmosphere, transient mass of condensate on the passive heat sinks, and steam lost to containment leakage. APP-PXS-M3C-072 (Reference 9) determines the percentage of losses as a function of flow from the containment vessel shell and this percent loss is bounded as an input to the WGOTHIC model. The Containment Analysis also provides the IRWST steaming rate, the PXS condensate flow rate and temperature, containment pressure, and CMT compartment temperature to the Safe Shutdown Temperature Evaluation (APP-SSAR-GSC-536, Reference 7). This analysis performs the Safe Shutdown Temperature Evaluation using the modified LOFTRAN computer code (described in DCD subsection 15.0.11.2).

The Shutdown Temperature Evaluation (Reference 7) and its analytical inputs implementing the variable condensate return fraction produced by the proposed changes demonstrate the efficacy of the proposed changes in helping to bring the RCS temperature to 420°F in less than 36 hours. Therefore, the plant continues to meet the licensing performance criterion established in SECY-94-084.

Changes to Chapter 19 will include changes to subsection 19E.4.10.2, Shutdown Temperature Evaluation, to describe the analysis methodology for a non-LOCA shutdown event, the time for the cold leg and core average temperatures to reach the specified safe, stable condition after shutdown following a loss of ac power event, and updates to corresponding tables and figures, which further detail the sequence of events. The changes to Chapter 19 are shown in Appendix B.

7.0 Regulatory Evaluation

The design changes and the changes to the licensing basis described in Sections 5.0 and 6.0 were evaluated against the NRC Interim Staff Guidance DC/COL-ISG-011 (Reference 4). That evaluation determined the changes are necessary to reflect a "significant technical correction associated with the design described in the licensing document that, if not changed, would preclude operation within the bounds of the licensing basis" (Reference 4). Specifically, without the changes described in Sections 5.0 and 6.0, the capability of the PRHR HX to maintain the RCS in a safe, stable condition as described in DCD Chapter 19E, "Shutdown Temperature Evaluation," would be challenged. Without the proposed changes, less condensate would be returned to the IRWST and the PRHR HX tubes would uncover sooner than anticipated. PRHR HX performance degrades as the heat exchanger tubes become uncovered. Without the proposed changes, the conclusions of the LOFTRAN shutdown temperature evaluation described in Chapter 19E.4.10.2 of DCD Revision 19 would have been inaccurate. Without the proposed changes, the descriptions of the Chapter 15 non-LOCA analyses would have required revision as well. Therefore, the changes meet the criteria for a change that should not be deferred during review of an application for a combined license.

This section provides an evaluation of the updated PXS condensate return design against the regulations satisfied by the PXS and analyses supporting the PXS design. In addition, a discussion of significant hazard considerations is included for informative purposes.

<u>Applicable Regulatory Requirements and Criteria</u>

Title 10 Code of Federal Regulations, Part 52, Appendix D, Section VIII applies to changes to Tier 1 and Tier 2 changes which involve changes to Tier 1 . The Tier 2 changes to the licensing basis described in Section 6.0 also require departures from Tier 1 information. Therefore, NRC approval is required prior to implementing the changes addressed in this departure.

Appendix A to 10 CFR Part 50:

1) General Design Criterion (GDC) 2, "Design bases for protection against natural phenomena," requires that the PXS be designed to withstand the effects of natural phenomena and normal and accident conditions without loss of capability to perform its safety functions.

   The PXS, including the additional PXS components added for the condensate return function, is designed to meet Seismic Category I design requirements; and is protected from the effects of external events such as earthquakes, tornadoes, and floods.

2) GDC 4, "Environmental and dynamic effects design bases," requires that the PXS be designed to accommodate the effects of and be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents.

   The PXS is designed to accommodate the environmental conditions associated with all modes of operation, and to prevent excessive dynamic events. Additionally, piping line sizes are selected to prevent steam flashing in the downspout piping. The additional piping and screens are constructed of materials compatible with the post-accident environment, consistent with DCD subsection 6.1.1.4.

3) GDC 5, "Sharing of structures, systems, and components," specifies that the PXS is prohibited from being shared among nuclear power units unless it can be demonstrated that sharing will not impair their ability to perform their safety function.

   The PXS contains no components that are shared between nuclear power units. Thus the PXS design to meets the requirements of GDC 5.

4) GDC 17, "Electric power systems," specifies that an onsite electric power system and an offsite electric power system be provided to provide sufficient capacity to ensure that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary (RCPB) are not exceeded and that the core is cooled during anticipated operational occurrences and accident conditions.

   The **AP1000** design does not require ac power sources to mitigate design-basis events. Likewise, the PXS condensate return design relies on natural forces; and does not require power sources to perform its safety-related functions. The components added are passive components maintained in their safety-related configuration for the duration of operation. Thus the **AP1000** design meets the requirements of GDC 17; and continues to support an exemption to the requirement of having two offsite power sources.

5) GDC 27, "Combined reactivity control systems capability," requires the PXS be designed to have a combined capability, in conjunction with poison addition, of reliably controlling reactivity changes to assure that, under postulated accident conditions and with appropriate margin for stuck rods, the capability to cool the core is maintained.

   The proposed changes do not affect the capability of the PXS to control core reactivity with poison addition. The proposed changes do affect the ability of the PXS to provide adequate core cooling by increasing the fraction of condensate returned to the IRWST during an event where steaming from the IRWST to containment occurs.

6) GDC 34, "Residual heat removal," requires the plant be designed with a residual heat removal system to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the RCPB are not exceeded.

   The PRHR HX is capable of cooling the RCS in accordance with the provisions of SECY-94-084. The changes proposed in this departure assure the percentage of condensate returned to the IRWST over time exceeds the return fraction necessary to ensure adequate PRHR HX performance. With the proposed changes, the updated safe shutdown evaluation continues to demonstrate that the plant complies with its functional requirement of cooling the RCS to 420°F within 36 hours. In addition, the extended design basis accident evaluation confirms compliance with the Chapter 15 non-LOCA acceptance criteria for 72 hours during the most limiting event.

7) GDC 35, "Emergency core cooling," requires the PXS be able to provide an abundance of core cooling to transfer heat from the core at a rate so that fuel and clad damage will not interfere with continued effective core cooling.

   The functionality of components of the PXS providing direct injection to the RCS for emergency core cooling is not affected by the changes in this departure. The changes described herein provide assurance the PRHR HX can provide adequate core cooling during non-LOCA events, in conjunction with core makeup tank and accumulator operation. Thus the PXS continues to satisfy GDC 35.

8) GDC 36, "Inspection of emergency core cooling system," requires the PXS be designed to permit appropriate periodic inspection of important components.

   The proposed modifications are accessible to periodic inspections. The proposed piping and downspout screens are accessible for inspection and maintenance as necessary. The PXS continues to comply with GDC 36.

9) GDC 37, "Testing of emergency core cooling system," requires the PXS be designed to permit appropriate periodic pressure and functional testing.

   The proposed modifications do not affect the ability to periodically test the emergency core cooling capability of the PXS. The periodic inspection and testing program for the PXS does not include requirements specifically for testing condensate return to the IRWST since steaming the containment is not practical. However, the added components are accessible for periodic inspection to confirm structural integrity and may be flow tested to confirm overall operability.

10) 10 CFR 50.46 and Appendix K to 10 CFR Part 50, as they relate to analysis of PXS performance, ensure the evaluation is accomplished in accordance with an acceptable evaluation model.

   The proposed design and licensing basis changes ensure the Chapter 6 and Chapter 15 safety analyses are not affected and remain bounding. The design basis analysis methods used to evaluate performance of the PXS include only methods approved for use by the Commission. The changes proposed do not include a new method of analysis.

<u>No Significant Hazards Consideration Determination</u> (provided for informative purposes only)

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

   Response: No.

   No accident previously evaluated in the plant-specific DCD is attributed to the failure of the condensate return features of the design. The proposed changes add passive components that do not rely on instrumentation and control systems to move them to a safe position. The proposed changes also meet applicable NRC general design criteria requirements. As the proposed changes do not involve any components that could initiate an event by means of component or system failure, the changes do not increase the probability of a previously evaluated accident.

   The added components are constructed of only those materials appropriately suited for exposure to the post-accident environment as described in DCD subsection 6.1.1.4. No aluminum is permitted to be used in the construction of these components to ensure they will not contribute to hydrogen production in containment. The changes do not alter design features available during normal operation or anticipated operational occurrences. Nonsafety-related features used for reactor coolant activity monitoring, or reactor coolant chemistry control remain unaffected. The changes do not adversely impact accident source term parameters or affect any release paths used in the safety analyses, which could increase radiological dose consequences. Thus the radiological releases associated with the Chapter 15 accident analyses are not affected.

As previously described, the proposed changes would not adversely affect the ability of the PRHR HX to meet the design requirements of GDCs 34 and 35. The proposed equipment does not adversely interact with or affect safety-related equipment or a radioactive material barrier. The components added by this change would not increase the consequences of an accident previously evaluated in the plant-specific DCD.

Therefore, the proposed changes do not involve a significant increase in the probability or consequences of an accident.

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

   Response: No.

   An evaluation of the downspout and gutter return subsystem determined the components are capable of acceptably performing their safety-related function, even if one of the downspouts were blocked. The new equipment does not interface with components in other systems that provide safety-related or defense-in-depth support to the plant, thus precluding the possibility condensate could be diverted to another system before reaching the gutter. The affected equipment does not interface with any component whose failure could initiate an accident, or any component that contains radioactive material. The modified components do not incorporate any active features relied upon to support normal operation. The downspout and gutter return components are seismically qualified to remain in place and functional during seismic and dynamic events. Consequently, the proposed component changes do not introduce new failure modes, interactions or dependencies, the malfunction of which could lead to new accident scenarios. Therefore, the proposed changes do not create the possibility for a new or different kind of accident.

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

   Response: No.

   The proposed changes do not involve a significant reduction in the margin of safety. The proposed changes do not reduce the redundancy or diversity of any safety-related functions. The proposed changes increase the amount of condensate available in the IRWST for heat transfer after shutdown, following a non-LOCA event with long-term loss of AC power. Though the fraction of condensate returned is slightly smaller than originally assumed, the proposed changes provide sufficient condensate return flow to maintain adequate IRWST water level for those events using the PRHR HX cooling function. While slightly lower condensate return rates result in a slightly earlier transition to PRHR HX uncover, the long-term shutdown temperature evaluation results show that the PRHR HX would continue to meet its acceptance criteria.

   The DCD Chapters 6 and 15 analyses results are not affected, thus margins to their regulatory acceptance criteria are unchanged. No design basis safety analysis or acceptance criterion is challenged or exceeded by the proposed changes, thus no margin of safety is reduced.

References

1) SECY-94-084, "Policy and Technical Issues Associated With the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," March 28, 1994
2) Appendix A to Part 50, Title 10 Code of Federal Regulations, General Design Criterion 34 - Residual heat removal
3) APP-GW-GL-700 Revision 19, "**AP1000** Design Control Document"
4) DC/COL-ISG-011, Final Interim Staff Guidance, Finalizing Licensing-basis Information, ML092890623, (Notice of Availability, ML092890577, November 2009).
5) WCAP-15846 (proprietary) and WCAP-15862 (nonproprietary), revision 1, "WGOTHIC Application to AP600 and **AP1000**."
6) [Not used]
7) APP-SSAR-GSC-536 Revision 3, "**AP1000** Safe Shutdown Temperature Evaluation," (proprietary).
8) APP-PXS-M3C-071 Revision 2, "Containment Response Analysis for Long-Term PRHR Operation," (proprietary).
9) APP-PXS-M3C-072 Revision 2, "Condensate Return to IRWST for Long Term PRHR Operation," (proprietary).
10) APP-FSAR-GF-006 Revision 0, "Levy County Units 1 & 2 Request for Additional Information Question 06.03-10, 06.03-11, and 06.03-12: Clarification of Passive Residual Heat Removal Heat Exchanger Design Requirements – Supplemental Response"
11) APP-FSAR-GF-007 Revision 0, "Levy County Units 1 & 2 Request for Additional Information Question 06.03-10, 06.03-11, and 06.03-12: Clarification of Passive Residual Heat Removal Heat Exchanger Design Requirements – Supplemental Response"

Note that the information contained in References 10 and 11 have been submitted to the NRC via DEF letter NPD-NRC-2014-021.

Appendix A:

Summary of Changes to the Technical Basis and Transient Analyses

A.1 Non-LOCA Event Considerations

A station blackout event is postulated to occur less than once during the 60 year lifetime of the **AP1000** plant. This event is postulated to occur as a result of a loss of offsite power, failure of the rapid power reduction system such that the turbine trips and then failure of the Onsite Standby Power System to initiate. This sequence of events results in a complete loss of alternating current (AC), or station blackout, at the site. When this occurs, the reactor will trip on low RCS flow. The wide range level in the steam generators will decrease below the Low setpoint. When this occurs, the protection and safety monitoring system (PMS) will automatically open the normally closed air-operated valves isolating the PRHR HX and initiate flow through the heat exchanger.

Within 2 to 4 hours after transient initiation (the exact time depends on assumptions of the transient analysis), the water in the IRWST will reach saturation due to energy deposition from the PRHR HX. Boiling and steam release from the IRWST will increase the containment pressure and temperature. Note that there is a good chance that AC power (either offsite or onsite) would be recovered in this time frame, such that long term PRHR HX operation is very unlikely. Passive Containment Cooling System (PCS) flow will be delivered through the PCS valves and initiate gravity driven sub-cooled liquid flow to the outside of the containment vessel from the passive containment cooling water storage tank (PCCWST) after the High containment pressure signal is reached. The PCS water flow provides evaporative cooling for the containment shell. Steam released in the containment will condense on the inside surface of the containment shell, and the condensate will be collected in the gutters and returned back to the IRWST.

During this transient, some of the steam that is generated by the PRHR HX will be returned to the IRWST. During the first phase of the transient, the steam which is released into containment from the IRWST will contact surfaces and equipment in containment that are initially at cooler temperatures. As a result, condensation will occur on these surfaces and result in loss of IRWST inventory. This condensation will continue until these structures heat up to the containment temperature. Another way steam will be lost is due to the pressurization of the containment atmosphere. Finally, steam will condense on the containment vessel surface. Most of this steam condensate is expected to drain back into the IRWST through the IRWST gutter. However, some of this condensate will be lost from droplets dripping from the central dome of the containment vessel where the slope of the containment vessel wall is not sufficient to allow the condensate to adhere and flow over to the vertical wall. As the condensate film flows down the vertical containment wall it will flow onto the polar crane girder, the internal stiffener, and the IRWST gutter.

In order to identify all of the important phenomena that result in condensate losses, a phenomena identification and ranking table was developed. The results show that the overall IRWST condensate return rate study should address the following.:

1. Dripping from containment dome surface
   a. Near-horizontal surface dripping
   b. Dripping from interferences (weld plate misalignment, support plates)
2. Losses from the containment sidewalls due to obstacles and entrance to gutter
3. Condensation on passive heat sinks with no drain to IRWST or gutters
4. Steam stored in containment atmosphere
5. Leakage from containment
6. Water entrainment from the IRWST that is not returned to the IRWST

A.2 Supporting Design Documentation

To address the previous items, the following testing program and calculation notes are used. Each of these documents will be available for inspection by the NRC.:

1. **AP1000** Condensate Return Test Report, TR-SEE-III-12-01
2. Containment Response Analysis for the Long Term PRHR Operation, APP-PXS-M3C-071
3. Condensate Return to IRWST for Long Term PRHR Operation, APP-PXS-M3C-072
4. **AP1000** Safe Shutdown Temperature Evaluation, APP-SSAR-GSC-536
5. **AP1000** Safe Shutdown Duration Evaluation, APP-SSAR-GSC-009
6. Extended Closed Loop PRHR HX Performance Under Saturation Conditions, APP-PXS-GSR-001

The following summarizes the content and purpose of each of these reports and explains the evaluation process established to provide required input for the IRWST condensate return rate analysis.

1. **AP1000** Condensate Return Test Report, TR-SEE-III-12-01

   This document reports the results of experiments performed to evaluate the condensate return rate along the vertical section of the containment vessel wall above the IRWST gutter and the amount of condensate captured by the IRWST gutter. The test configuration, and results are summarized in Section 4.0.

2. Containment Response Analysis for the Long Term PRHR Operation, APP-PXS-M3C-071

   The WGOTHIC **AP1000** containment model was developed to perform the containment peak pressure and temperature response calculations for the design analyses presented in Chapter 6 of the DCD. The approved methodology for that application uses conservative assumptions that tend to reduce the steam condensation heat and mass transfer rates and increase the calculated containment pressure/temperature response. To this end, the model does not take credit for all of the passive heat sinks that are located inside the containment vessel.

   The purpose of the calculations documented in APP-PXS-M3C-071 is to quantify the following thermodynamic phenomena:

   - Containment pressure and temperature,
   - Losses due to condensation on passive heat sinks,
   - Losses due to containment leakage,
   - Mass of steam which remains in containment free volume,
   - IRWST steaming rate,
   - PXS condensate return flow rate and temperature, and
   - CMT Compartment temperature.

   The WGOTHIC **AP1000** containment model is the best tool available for performing these calculations. However, for this application, the heat transfer areas for all of the passive heat sinks in the model must be increased to account for those that were not included for the containment peak pressure/temperature application. In addition, sensitivity studies must be performed to identify the most conservative initial and boundary conditions for this application. The changes that are required to be made to the WGOTHIC **AP1000** containment model for this application are described in further detail in APP-PXS-M3C-071.

The WGOTHIC basedeck uses conservative inputs and initial conditions for the design basis analysis. Sensitivity analyses were performed with several sets of initial conditions/inputs in order to determine the most conservative set of input for the design basis case. The following input/boundary conditions were analyzed:

- Heat Input to the PRHR HX,
- PCS flow, PCS water temperature, PCS water coverage,
- Containment vessel heat transfer rates,
- PCS actuation time,
- IRWST water level, water temperature,
- Containment initial pressure, temperature, relative humidity,
- Mass of the heat sinks inside the containment, and
- PRHR Tube Plugging sensitivities.

The resulting evaluation in APP-PXS-M3C-071 provides input to APP-PXS-M3C-072 and to APP-SSAR-GSC-536.

3. Condensate Return to IRWST for Long Term PRHR Operation, APP-PXS-M3C-072

The purpose of the APP-PXS-M3C-072 calculation note is to perform the Condensate Return evaluation. This calculation takes inputs from APP-PXS-M3C-071, including;

- Containment pressure and temperature,
- Losses due to condensation on passive heat sinks,
- Losses due to containment leakage, and
- Mass of steam which remains in containment free volume.

This calculation provides the mass of steam that remains in the free containment volume which contributes to pressurization, mass of the steam that will condense on the heat sinks, mass of the steam that will be lost through containment leakage, and inventory losses that will occur on the containment vessel head and containment vessel sidewalls considering test data reported in TR-SEE-III-12-01.

.] This calculation considers the following phenomena previously identified.

- Dripping from containment inside surface (upper dome), "rain out phenomenon"
- Dripping from containment inside surface (upper dome) due to the containment plates misalignment (interference dripping)
- Obstacle-induced dripping from the containment dome
- Obstacle-induced dripping from the containment sidewalls.
- Water entrainment from the IRWST

4. **AP1000** Safe Shutdown Temperature Evaluation, APP-SSAR-GSC-536

The purpose of APP-SSAR-GSC-536 is to perform the Safe Shutdown Temperature Evaluation. This cooldown analysis evaluates two specific cases, time to Safe Shutdown (420°F in 36 hours) and the Design Basis Analysis Extension case (72 hours with Chapter 15 acceptance criteria).

The inputs for this analysis are taken from APP-PXS-M3C-071, including:

- Containment Pressure,
- Containment Temperature,
- IRWST steaming rate,
- PXS condensate return flow rate and temperature, and
- CMT Compartment temperature.

The Safe Shutdown Temperature evaluation, which is performed with the LOFTRAN computer code and is documented in Chapter 19E of DCD Revision 19, demonstrates the capability of the PRHR HX to reduce the core average temperature to 420 °F within 36 hours after shutdown following any design basis transient. The loss of normal feedwater with coincident loss of AC power is the most limiting transient with respect to removal of core decay heat; and is used to demonstrate that the passive safety systems can bring the plant to a stable, safe condition.

In addition to the 36 hour Safe Shutdown temperature evaluation, this analysis includes an extended design basis accident case. This case is considered to demonstrate that the Chapter 15 non-LOCA acceptance criteria are met for 72 hours (including maximum primary and secondary pressures, minimum departure from nucleate boiling ratio (DNBR), and maximum pressurizer water volume).

The Safe Shutdown temperature evaluation relies on the IRWST to reduce the core average temperature, and is therefore sensitive to condensate return rate. This evaluation is being revised to reflect updates incorporated in the approved DCD Revision 19 design, as well as the condensate return insights and design changes described in Sections 4.0 and 5.0 of this report.

5. **AP1000** Safe Shutdown Duration Evaluation, APP-SSAR-GSC-009

   The purpose of APP-SSAR-GSC-009 is to perform the Safe Shutdown Temperature Duration Evaluation. This cooldown analysis evaluates the duration the **AP1000** plant can maintain safe shutdown for greater than 14 days, using conservative, non-bounding assumptions. This analysis is an extension of APP-SSAR-GSC-536.

6. Extended Closed Loop PRHR HX Performance Under Saturation Conditions, APP-PXS-GSR-001

   The purpose of this document is to provide an engineering basis to justify the applicability of the LOFTRAN computer code to perform extended station blackout scenarios. Specifically, this report examines the following limitations of LOFTRAN:

   - The ability to mechanistically account for uncovery of the lower PRHR HX tube region considering LOFTRAN's single flow path nodalization in the PRHR loop circuit.
   - The ability to account for the effects of loss of sub-cooling in the RCS when the extent of voiding extends beyond the pressurizer and upper heat of the reactor vessel.

   The document concludes that LOFTRAN is an appropriate code and the limitations identified lead to a representative prediction of Tavg for long term station blackout (SBO) scenarios. This conclusion is reached through a review of applicable test data and a supporting RELAP analysis that models reactor coolant system heat losses to understand the impact of sub-cooling on PRHR operations.

[

] (a,c)

Test Database Review

After review of the testing database, two tests were identified for further evaluation, NRC-5102 and an SBLOCA test at the APEX facility.

[

] (a,c)

Conclusion

The tests reviewed in the test database, NRC-5102 and APEX 0.5" SBLOCA, demonstrated that PRHR flow and energy removal capability are not degraded during an event where loss of sub-cooling was achieved in the RCS and in the presence of large void formations. The confirmatory RELAP analyses demonstrates that a loss of RCS sub-cooling will not result in degradation of PRHR performance, and demonstrates that modeling ambient heat losses in the RCS yielded lower values of Tavg than that of adiabatic conditions. The RELAP evaluation also demonstrates that, consistent with LOFTRAN, the lower PRHR HX tube bundle does not begin to uncover during the 14 day mission time of the PRHR HX.

Therefore, LOFTRAN's treatment of the lower PRHR HX tube bundle uncover is not pertinent to the analysis results.

A.3 Not used

Appendix B

Marked up pages of the plant-specific DCD

Tier 1 Markups

Condensate Return

Table 2.2.3-1

Equipment Name	Tag No.	ASME Code Section III	Seismic Cat. I	Remotely Operated Valve	Class 1E/ Qual. Harsh Envir.	Safety-Related Display	Control PMS/ DAS	Active Function	Loss of Motive Power Position
Passive Residual Heat Removal Heat Exchanger (PRHR HX)	PXS-ME-01	Yes	Yes	-	- / -	-	- / -	-	-
Accumulator Tank A	PXS-MT-01A	Yes	Yes	-	- / -	-	- / -	-	-
Accumulator Tank B	PXS-MT-01B	Yes	Yes	-	- / -	-	- / -	-	-
Core Makeup Tank (CMT) A	PXS-MT-02A	Yes	Yes	-	- / -	-	- / -	-	-
CMT B	PXS-MT-02B	Yes	Yes	-	- / -	-	- / -	-	-
IRWST	PXS-MT-03	No	Yes	-	- / -	-	- / -	-	-
IRWST Screen A	PXS-MY-Y01A	No	Yes	-	- / -	-	- / -	-	-
IRWST Screen B	PXS-MY-Y01B	No	Yes	-	- / -	-	- / -	-	-
IRWST Screen C	PXS-MY-Y01C	No	Yes	-	- / -	-	- / -	-	-
Containment Recirculation Screen A	PXS-MY-Y02A	No	Yes	-	- / -	-	- / -	-	-
Containment Recirculation Screen B	PXS-MY-Y02B	No	Yes	-	- / -	-	- / -	-	-
pH Adjustment Basket 3A	PXS-MY-Y03A	No	Yes	-	- / -	-	- / -	-	-
pH Adjustment Basket 3B	PXS-MY-Y03B	No	Yes	-	- / -	-	- / -	-	-
pH Adjustment Basket 4A	PXS-MY-Y04A	No	Yes		- / -		- / -		
pH Adjustment Basket 4B	PXS-MY-Y04B	No	Yes		- / -		- / -		
Downspout Screen 1A	PXS-MY-Y81	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 1B	PXS-MY-Y82	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 1C	PXS-MY-Y83	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 1D	PXS-MY-Y84	No	Yes	-	- / -	-	- / -	-	-

Note: Dash (-) indicates not applicable.

Table 2.2.3-1 (cont.)									
Equipment Name	**Tag No.**	**ASME Code Section III**	**Seismic Cat. I**	**Remotely Operated Valve**	**Class 1E/ Qual. Harsh Envir.**	**Safety-Related Display**	**Control PMS/ DAS**	**Active Function**	**Loss of Motive Power Position**
Downspout Screen 2A	PXS-MY-Y85	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 2B	PXS-MY-Y86	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 2C	PXS-MY-Y87	No	Yes	-	- / -	-	- / -	-	-
Downspout Screen 2D	PXS-MY-Y88	No	Yes	-	- / -	-	- / -	-	-
CMT A Inlet Isolation Motor-operated Valve	PXS-PL-V002A	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/No	None	As Is
CMT B Inlet Isolation Motor-operated Valve	PXS-PL-V002B	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/No	None	As Is
CMT A Discharge Isolation Valve	PXS-PL-V014A	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/Yes	Transfer Open	Open
CMT B Discharge Isolation Valve	PXS-PL-V014B	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/Yes	Transfer Open	Open
CMT A Discharge Isolation Valve	PXS-PL-V015A	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/Yes	Transfer Open	Open
CMT B Discharge Isolation Valve	PXS-PL-V015B	Yes	Yes	Yes	Yes/Yes	Yes (Position)	Yes/Yes	Transfer Open	Open
CMT A Discharge Check Valve	PXS-PL-V016A	Yes	Yes	No	- / -	No	- / -	Transfer Open/ Transfer Closed	-
CMT B Discharge Check Valve	PXS-PL-V016B	Yes	Yes	No	- / -	No	- / -	Transfer Open/ Transfer Closed	-

Note: Dash (-) indicates not applicable.

Table 2.2.3-2 (cont.)				
Line Name	**Line Number**	**ASME Code Section III**	**Leak Before Break**	**Functional Capability Required**
IRWST screen cross-connect line	PXS-L180A, PXS-L180B	Yes	No	Yes
Containment recirculation line A	PXS-L113A, PXS-L131A, PXS-L132A	Yes	No	Yes
Containment recirculation line B	PXS-L113B, PXS-L131B, PXS-L132B	Yes	No	Yes
IRWST gutter drain line	PXS-L142A, PXS-L142B	Yes	No	Yes
	PXS-L141A, PXS-L141B	Yes	No	No
Downspout drain lines from polar crane girder and internal stiffener to collection box A	PXS-L301A, PXS-L302A, PXS-L303A, PXS-L304A, PXS-L305A, PXS-L306A, PXS-L307A, PXS-L308A, PXS-L309A, PXS-L310A	Yes	No	Yes
Downspout drain lines from polar crane girder and internal stiffener to collection box B	PXS-L301B, PXS-L302B, PXS-L303B, PXS-L304B, PXS-L305B, PXS-L306B, PXS-L307B, PXS-L308B, PXS-L309B, PXS-L310B	Yes	No	Yes

Tier 2 Markups

Condensate Return

AP1000 Response:

The AP1000 incorporates the NRC criteria. The heat load is evaluated for the spent fuel storage capacity.

A-29 Nuclear Power Plant Design for the Reduction of Vulnerability to Industrial Sabotage

Description

This item addresses potential methods to reduce vulnerability to sabotage. The NRC staff concluded that existing requirements dealing with plant physical security, controlled access to vital areas, screening for reliable personnel appear to be effective. This item was resolved with no new requirements.

AP1000 Response:

The passive systems in the AP1000 provided to mitigate the effects of potential accidents may have an inherent advantage when considering potential acts of sabotage compared to the active systems in operating plants. The AP1000 includes provisions for access control to the vital area. The provisions for security are discussed in the AP1000 Security Design Report and outlined in Section 13.6.

A-31 Residual Heat Removal Requirements

Discussion:

Generic Issue A-31 addresses the desire for plants to be able to go from hot-standby to cold-shutdown conditions (when this is determined to be the safest course of action) under an accident condition. The safe shutdown of a nuclear power plant following an accident not related to a loss-of-coolant accident has been typically interpreted as achieving a hot standby condition (the reactor is shut down, but system temperature and pressure are at or near normal operating values). There are events that require eventual cooldown and long-term cooling to perform inspection and repairs.

AP1000 Response:

The AP1000 employs safety-related core decay heat removal systems that establish and maintain the plant in a safe, stable ~~shutdown~~ condition following design basis events. It is not necessary that these passive systems achieve cold shutdown as defined by Regulatory Guide 1.139.

The AP1000 complies with General Design Criteria 34 by using a more reliable and simplified system design. The passive core cooling system is employed for both hot-standby and long-term cooling modes. Hot-standby conditions are achieved immediately and a temperature of 420°F is reached within 36 hours as discussed in subsection 19E.4.10.2. Reactor pressure is controlled and can be reduced to about 250 psig. The passive residual heat removal system provides a closed cooling system to maintain long-term core cooling. Passive feed and bleed cooling, using the passive injection features for the feed and the automatic depressurization system for bleed, provides ~~another closed-loop~~ safety-related cooling capability. ~~This capability eliminates~~

~~dependency on open-loop cooling systems, which have limited ability to remain in hot standby for long-term core cooling.~~ See Section 7.4 for a discussion of safe shutdown and Section 6.3 for a description of the passive core cooling system.

Since the passive core cooling system maintains safe conditions indefinitely, cold shutdown is necessary only to gain access to the reactor coolant system for inspection or repair. On the AP1000, cold shutdown is accomplished by using non-safety-related systems. These systems are highly reliable. They have similar redundancy as current generation safety-related systems and are supplied with ac power from either onsite or offsite sources. See subsection 5.4.7 for a description of the normal residual heat removal system and subsection 7.4.1.3 for a discussion of cold shutdown achieved by use of non-safety-related systems.

A-35 Adequacy of Offsite Power Systems

Discussion:

Generic Issue A-35 addresses the susceptibility of safety-related electric equipment to offsite power source degradation. The NRC considers this issue as technically resolved with the issuance of the Standard Review Plan, Section 8.3.1 criteria specified in Appendix A, Branch Technical Position BTP PSB 1, "Adequacy of Station Electric Distribution System Voltages."

AP1000 Response:

The AP1000 ac power system is discussed in subsections 8.1 through 8.3. The AP1000 does not require any ac power source to achieve and maintain safe shutdown.

A-36 Control of Heavy Loads Near Spent Fuel

Discussion:

Generic Issue A-36 addresses the need to review requirements, facility designs, and Technical Specifications regarding the movement of heavy loads near spent fuel. The NRC has documented its technical position on this issue in NUREG-0612 (Reference 10) and that issued Standard Review Plan, Section 9.1.5, which includes NUREG-0612 as a part of the review plan.

AP1000 Response:

The AP1000 design conforms to NUREG-0612 and Standard Review Plan, Section 9.1.5. Light load handling systems are described in subsection 9.1.4, and overhead heavy-load handling systems are described in subsection 9.1.5.

A-39 Determination of Safety Relief Valve Pool Dynamic Loads and Temperature Limits for BWR Containments

Discussion:

Generic Issue A-39 addresses operation of BWR primary system pressure relief valves whose operation can result in hydrodynamic loads on the suppression pool retaining structures or those

- The automatic depressurization system first-, second-, and third-stage valves, connected to the top of the pressurizer, are open whenever the core makeup tanks are blocked during shutdown conditions while the reactor vessel upper internals are in place. This provides a vent flow path to preclude pressurization of the reactor coolant system during shutdown conditions when decay heat removal is lost. This also allows the in-containment refueling water storage tank to automatically provide injection flow if it is actuated on a sustained loss of decay heat removal.

Administrative controls require containment closure capability in modes 5 and 6, during reduced inventory operations, and when the upper internals are in place. Containment closure capability is defined as the capability to close the containment prior to core uncovery following a loss of the normal decay heat removal system (that is, normal residual heat removal system). The containment design also includes penetrations for temporary cables and hoses needed for shutdown operations. These penetrations are isolated in an emergency.

In addition to these design features, appropriate procedures are defined to guide and direct the operator in the proper conduct of midloop operation and to aid in identifying and correcting abnormal conditions that might occur during shutdown operations.

1.9.5.1.5 Station Blackout

NRC Position:

The NRC has issued NUREG-0649 (Reference 34), NUREG-1032 (Reference 35), and NUREG-1109 (Reference 36) to address the unresolved safety issue of station blackout (USI-44). See subsection 1.9.4 for a discussion of USI-44.

To resolve this issue, the NRC published 10 CFR 50.63 and Regulatory Guide 1.155, which establish new requirements so that an operating plant can safely shut down following a loss of all ac power. SECY-94-084 (Reference 67), discusses station blackout for passive plants.

AP1000 Response:

The AP1000 is in conformance with the NRC guidelines for station blackout.

The AP1000 design minimizes the potential risk contribution of station blackout by not requiring ac power sources for design basis events. Safety-related systems do not need nonsafety-related ac power sources to perform safety-related functions.

The AP1000 safety-related passive systems automatically establish and maintain safe, stable ~~shutdown~~ conditions for the plant following design basis events, including an extended loss of ac power sources. The passive systems can maintain these safe, stable ~~shutdown~~ conditions after design basis events for at least 72 hours, without operator action, following a loss of both onsite and offsite ac power sources. Subsection 1.9.5.4 provides additional information on long-term actions following an extended station blackout beyond 72 hours.

The AP1000 also includes redundant nonsafety-related onsite ac power sources (diesel-generators) to provide electrical power for the nonsafety-related active systems which provide defense in depth.

AP1000 design features that mitigate the consequences of a station blackout are as follows:

- A full-load rejection capability to reduce the probability of loss of onsite power
- Safety-related passive residual heat removal heat exchanger
- Safety-related passive containment cooling
- Bleed and feed capability, using the safety-related automatic depressurization system in conjunction with the water available from the core makeup tanks, the accumulators, and the in-containment refueling water storage tank
- Class 1E batteries sized for 72 hours of operation under station blackout conditions
- Nonsafety-related reserve auxiliary transformers to provide power to selected ac power systems
- A nonsafety-related ac power system that includes two diesel-generators that automatically start on loss of offsite power
- An automatic nonsafety-related load-sequencing circuit that starts the following redundant nonsafety-related equipment after a loss of offsite power, once the associated diesel-generator is started:
  - Startup feedwater pump
  - Component cooling water pump
  - Service water pump
- Reactor coolant pumps without shaft seals
- Passive cooling for the rooms containing equipment assumed to operate during station blackout conditions (the protection and safety monitoring system cabinet rooms and the main control room) so that this equipment continues to operate. (Section 6.4 provides additional information.)

1.9.5.1.6 Fire Protection

NRC Position:

Current fire protection criteria are contained in GDC 3 and 10 CFR 50.48, guidelines for compliance with these criteria are provided in the Standard Review Plan, Section 9.5.1, including Branch Technical Position CMEB 9.5-1. Reference 9 identifies the following enhancements:

- Alternative, dedicated shutdown capability for main control room fires.

Table 3.2-3 (Sheet 16 of 75)

AP1000 CLASSIFICATION OF MECHANICAL AND FLUID SYSTEMS, COMPONENTS, AND EQUIPMENT

Tag Number	Description	AP1000 Class	Seismic Category	Principal Construction Code	Comments
Passive Core Cooling System (Continued)					
PXS-MY-Y01C	IRWST Screen C	C	I	Manufacturer Std.	Structural frame and attachment use ASME III, Subsection NF criteria. Screen modules use manufacturer std.
PXS-MY-Y02A	Containment Recirculation Screen A	C	I	Manufacturer Std.	Structural frame and attachment use ASME III, Subsection NF criteria. Screen modules use manufacturer std.
PXS-MY-Y02B	Containment Recirculation Screen B	C	I	Manufacturer Std.	Structural frame and attachment use ASME III, Subsection NF criteria. Screen modules use manufacturer std.
PXS-MY-Y03A	pH Adjustment Basket A	C	I	Manufacturer Std.	
PXS-MY-Y03B	pH Adjustment Basket B	C	I	Manufacturer Std.	
PXS-MY-Y03C	pH Adjustment Basket C	C	I	Manufacturer Std.	
PXS-MY-Y03D	pH Adjustment Basket [rmk144]D	C	I	Manufacturer Std.	
PXS-MY-Y81	Downspout Screen 1A	C	I	Manufacturer Std.	
PXS-MY-Y82	Downspout Screen 1B	C	I	Manufacturer Std.	
PXS-MY-Y83	Downspout Screen 1C	C	I	Manufacturer Std.	
PXS-MY-Y84	Downspout Screen 1D	C	I	Manufacturer Std.	
PXS-MY-Y85	Downspout Screen 2A	C	I	Manufacturer Std.	
PXS-MY-Y86	Downspout Screen 2B	C	I	Manufacturer Std.	
PXS-MY-Y87	Downspout Screen 2C	C	I	Manufacturer Std.	
PXS-MY-Y88	Downspout Screen 2D	C	I	Manufacturer Std.	
PXS-PL-V002A	CMT A CL Inlet Isolation	A	I	ASME III-1	
PXS-PL-V002B	CMT B CL Inlet Isolation	A	I	ASME III-1	

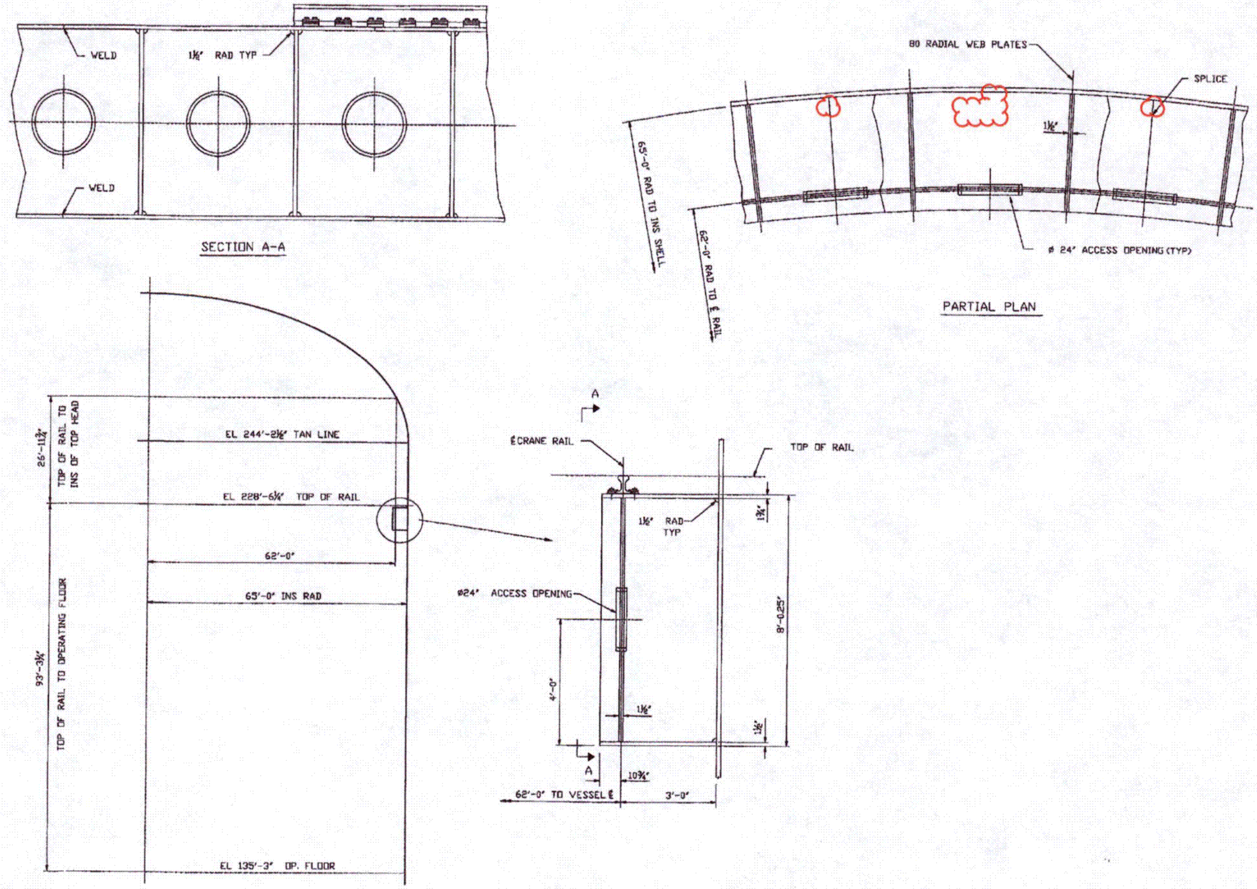

Figure 3.8.2-1 (Sheet 3 of 3)

Containment Vessel General Outline

5.4.11.2 System Description

Each safety valve discharge is directed to a rupture disk at the end of the discharge piping. A small pipe is connected to the discharge piping to drain away condensed steam leaking past the safety valve. The discharge is directed away from any safety related equipment, structures, or supports that could be damaged to the extent that emergency plant shutdown is prevented by such a discharge.

The discharge from each of two groups of automatic depressurization system valves is connected to a separate sparger below the water level in the in-containment refueling water storage tank. The piping and instrumentation diagram for the connection between the automatic depressurization system valves and the in-containment refueling water storage tank is shown in Figure 6.3-~~2~~1. The in-containment refueling water storage tank is a stainless steel lined compartment integrated into the containment interior structure. The discharge of water, steam, and gases from the first-stage automatic depressurization system valves when used to vent noncondensable gases does not result in pressure in excess of the in-containment refueling water storage tank design pressure. Additionally, vents on the top of the tank protect the tank from overpressure, as described in subsection 6.3.2.

Overflow provisions prevent overfilling of the tank. The overflow is directed into the refueling cavity. The in-containment refueling water storage tank does not have a cover gas and does not require a connection to the waste gas processing system. The normal residual heat removal system provides nonsafety-related cooling of the in-containment refueling water storage tank.

5.4.11.3 Safety Evaluation

The design of the control for the reactor coolant system and the volume of the pressurizer is such that a discharge from the safety valves is not expected. The containment design pressure, which is based on loss of coolant accident considerations, is greatly in excess of the pressure that would result from the discharge of a pressurizer safety valve. The heat load resulting from a discharge of a pressurizer safety valve is considerably less than the capacity of the passive containment cooling system or the fan coolers. See Section 6.2.

Venting of noncondensable gases, including entrained steam and water from the loop seals in the lines to the automatic depressurizations system valves, from the pressurizer into spargers below the water line in the in-containment refueling water storage tank does not result in a significant increase in the pressure or water temperature. The in-containment refueling water storage tank is not susceptible to vacuum conditions resulting from the cooling of hot water in the tank, as described in subsection 6.3.2. The in-containment refueling water storage tank has capacity in excess of that required for venting of noncondensable gases from the pressurizer following an accident.

5.4.11.4 Instrumentation Requirements

The instrumentation for the safety valve discharge pipe, containment, and in-containment refueling water storage tank are discussed in subsections 5.2.5, 5.4.9, and in Sections 6.2 and 6.3, respectively. Separate instrumentation for the monitoring of the discharge of noncondensable gases is not required.

5.4.14.1 Design Bases

The passive residual heat removal heat exchanger~~s~~ automatically actuates to remove~~s~~ core decay heat for 72 hours ~~an unlimited period of time~~as discussed in Section 6.3, assuming the condensate from steam generated in the in-containment refueling water storage tank (IRWST) is returned to the tank. The passive residual heat removal heat exchanger is designed to withstand the design environment of 2500 psia and 650°F.

The passive residual heat removal heat exchanger and the in-containment refueling water storage tank are designed to delay significant steam release to the containment for at least one hour. The passive residual heat removal heat exchanger will ~~keep the reactor coolant subcooled and prevent water relief from the pressurizer.~~

~~The passive residual heat removal heat exchanger in conjunction with the passive containment cooling system can remove heat for an indefinite time in closed loop (that is, no pipe break) mode of operation.~~ remove sufficient decay heat from the reactor coolant system to satisfy the applicable post-accident safety evaluation criteria detailed in Chapter 15 for at least 72 hours. In addition, the passive residual heat removal heat exchanger will cool the reactor coolant system, with reactor coolant pumps operating or in the natural circulation mode, so that the reactor coolant system ~~can be~~pressure can be lowered ~~depressurized~~ to reduce stress levels in the system if required. See Section 6.3 for a discussion of the capability of the passive core cooling system.

The passive residual heat removal heat exchanger is designed and fabricated according to the ASME Code, Section III, as a Class 1 component. Those portions of the passive residual heat exchanger that support the primary-side pressure boundary and falls under the jurisdiction of ASME Code, Section III, Subsection NF are AP1000 equipment Class A (ANS Safety Class 1, Quality Group A). Stresses for ASME Code, Section III equipment and supports are maintained within the limits of Section III of the Code. Section 5.2 provides ASME Code, Section III and material requirements. Subsection 5.2.4 discusses inservice inspection.

Materials of construction are specified to minimize corrosion/erosion and to provide compatibility with the operating environment, including the expected radiation level. Subsection 5.2.3 discusses the welding, cutting, heat treating and other processes used to minimize sensitization of stainless steel.