ENCLOSURE 4

APP-GW-GLR-097 Revision 0 (Non-Proprietary)

"Evaluation of the Effect of the AP1000 Enhanced Shield Building Design on the Containment Response and Safety Analyses"

(Non-Proprietary)

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Evaluation of the Effect of the AP1000™ Enhanced Shield Building Design on the Containment Response and Safety Analyses

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1.0 Introduction

The AP1000™[1] shield building design is being modified to increase structural integrity, enhance the overall seismic safety margin, and simplify construction. Some of the design changes impact the air flow rate through the Passive Containment Cooling System (PCS). The PCS air flow rate, along with evaporation of the water film that is applied to the outer steel surface of the containment shell, promotes cooling and depressurization of the containment during postulated accident conditions. This report summarizes the effect of the shield building design changes on the PCS operation and the pressure response of the containment as analyzed in the AP1000 safety analyses.

The purpose of this report is to evaluate the effect of the shield building PCS air inlet/outlet design changes on the containment response and safety analyses documented in the Design Control Document (DCD). The containment response for the design basis accident (DBA) events and a representative beyond design basis accident (BDBA) event are presented to show the effect of these design changes on the AP1000 safety analysis.

This report covers the following topics:

- Description of the PCS Air Inlet/Outlet Design Changes
- Impact of the PCS Air Inlet/Outlet Design Changes on the PIRT, Scaling, and Test Results
- Description of the Changes to the WGOTHIC AP1000 Containment Evaluation Model
- DBA Event Results
- Representative BDBA Event Results
- Description of the Airflow Path Surveillance Frequency
- Required Markups for DCD Rev. 18

The results of this design change evaluation show that the AP1000 containment pressure response is essentially the same for the DBA events, and that the conclusions reached for the BDBA events remain valid.

This report supersedes AP1000 Standard Combined License Technical Report 143, APP-GW-GLN- 143, "Evaluation of the Effect of Shield Building Changes on Containment Response and Safety Analyses".

2.0 Operation of the PCS

The PCS is a safety-related system capable of transferring heat directly from the steel containment vessel to the environment. This transfer of heat maintains the containment below the design limit of 59 psig (406.8 kPag) following a postulated design basis accident, and reduces the containment pressure and temperature in the longer term.

A schematic of the AP1000 PCS is shown in Figure 2-1. The PCS consists of the steel containment vessel, the air flow path that is formed in the annulus between the shield building and the containment vessel, a water storage tank (with associated pipes and valves), and weirs to distribute the water onto the surface of the containment vessel. The air flow path also includes the air inlets, a baffle structure between the containment and shield building, and an air discharge/exhaust chimney structure.

[1] AP1000™ is a registered trademark of Westinghouse Electric Company LLC.

The space between the steel shell and concrete shield building is designed to provide a natural circulation path for the air to flow through. Baffle plates separate this space into an inner and outer annulus. The width of the inner annulus, that is located between the containment shell and baffle plates, is about 1/3 the width of the outer annulus, that is located between the baffle plates and the concrete shield building. Air that is drawn through the openings located near the top of the cylindrical portion of the concrete shield building, flows downward through the outer annulus, turns 180 degrees, and then flows upward through the narrower inner annulus along the outer surface of the containment shell. The reduction in flow area between the outer and inner annulus increases the air velocity against the outer surface of the containment shell. After rising through the inner annulus, the air expands into a large open plenum above the dome of the containment shell. The PCS exhaust structure is a large cylindrical chimney at the top-center of the shield building. Air from the plenum above the dome passes through a "bird cage" and is compressed at the entrance to the chimney. After traveling upward through the chimney, it passes through a grate and is exhausted to the environment.

Air continually flows through the PCS annulus during normal operation of the plant due to the heating from the relatively warm containment shell or as induced by wind acting on the exterior of the shield building. The density of the heated air in the inner annulus is lower than the air in the outer annulus and outside the shield building. This causes a buoyancy-driven, natural circulation flow rate. Wind blowing across the chimney at the exit also induces a differential pressure that draws air through the annulus.

The PCS is designed to limit the increase in containment pressure and temperature following a postulated accident that releases steam inside the containment. The steam will condense on the inside surface of the containment shell. The condensation process releases heat that is conducted through the steel shell and into the PCS air flow path.

The PCS is required by the Technical Specification to be operable in Modes 1 through 4. Manual actuation of the PCS is relied on if automatic actuation is inoperable in Modes 5 and 6. The application of PCS water to the external surface of the containment shell is initiated in response to a Hi-2 containment pressure. No operator action is required for at least 3 days to adjust the applied water flow rate or to replenish the passive containment cooling water supply. The water simply drains by gravity from the water storage tank that is incorporated into the shield building structure above the containment. The water is distributed by two sets of weirs on top of the containment shell to produce a film for evaporative cooling.

The buoyancy-driven PCS air flow rate increases as heat and water vapor is transferred from the containment shell to the air in the inner annulus. The flow rate is limited by the resistance of the PCS air flow path, which consists of both form losses due to contractions, expansions and turns, as well as the friction losses along the flow path. The buoyancy-driven flow rate provides natural convection cooling of the containment shell.

As described above, the PCS heat removal from the inside of containment to the external environment occurs through the condensation, conduction, evaporation, convection, and radiation heat transfer mechanisms.

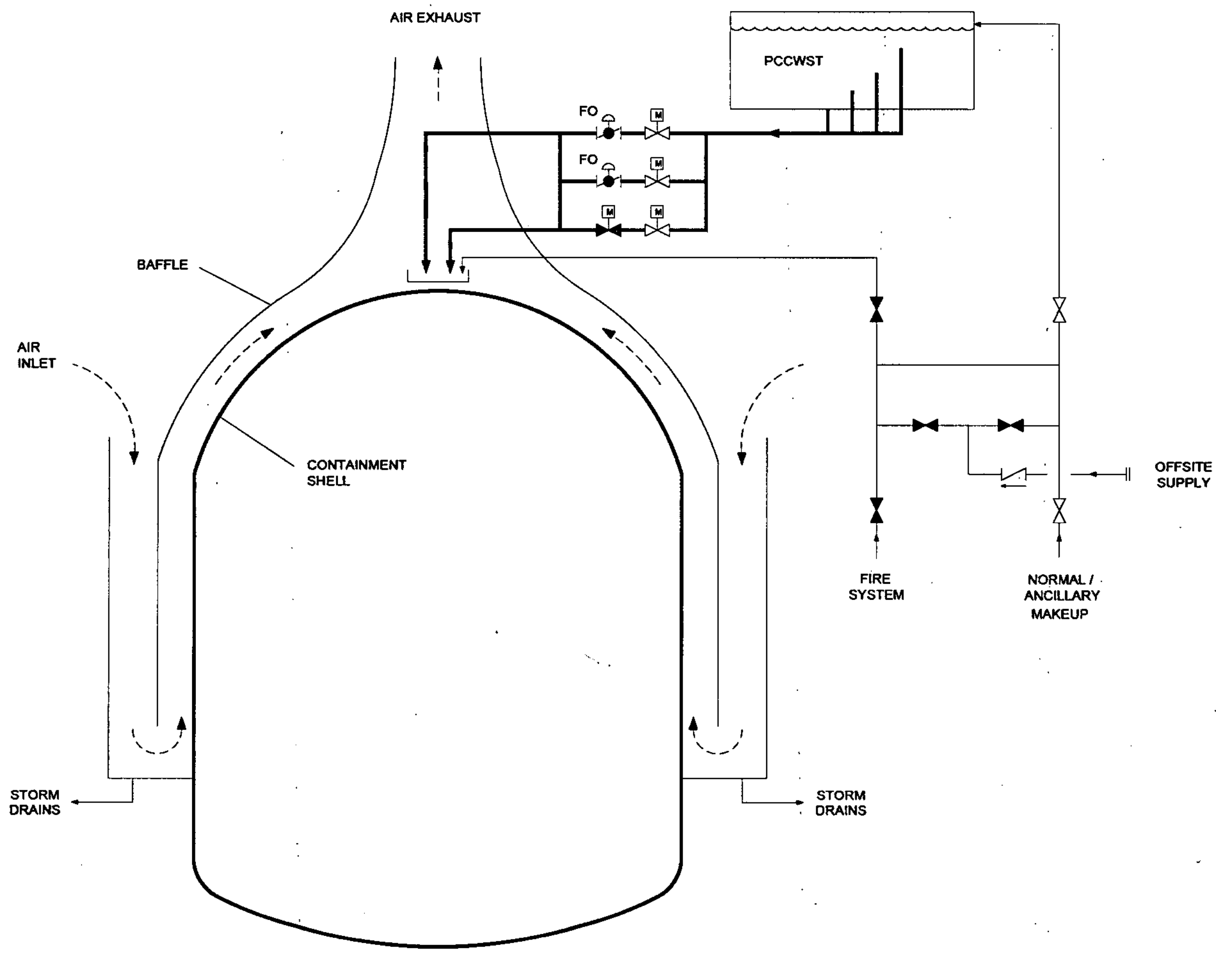


Figure 2-1: AP1000 Passive Containment Cooling System Schematic

3.0 Description of the PCS Air Inlet/Outlet Design Changes

The original air inlet design of the AP1000 shield building had 15 large openings to admit air into the PCS. These openings were distributed uniformly around the top of the cylindrical portion of the shield building, and contained fixed, always open, louvers and screens to prevent weather (rain, snow, ice) and wildlife from entering the shield building. The openings admitted outside air into a common plenum inside the shield building that transitions to the outer flow annulus. This air inlet design was approved by the NRC as part of the AP1000 Design Certification.

New regulations made it necessary to revise the shield building design to make it more robust to seismic events and potential additional threats such as an aircraft crash. The shield building design changes for the air inlet and outlet are expected to increase the resistance for air flow through the PCS. Also, the reduced height of the enhanced shield building design is expected to slightly decrease the buoyant driving head for the air/vapor mixture flowing through the PCS. The effects of these design changes must be evaluated with respect to the containment response and safety analyses.

In the revised air inlet design, a steel structure containing the fixed, always open louvers and screens has been added around the top of the shield building as shown in Figure 3-1. This steel structure contains 29 air openings that are 9 ft high by 10 ft long. The flow area through the revised louvers and screens is higher than it was through the original louvers, screens and inlet ducts [ ]^{a,c}.

After passing through the screens, the air enters the common plenum that is formed by the steel structure and the outside of the concrete shield building and continues through 236 air inlet ducts. [ ]^{a,c} The flow area through the revised air inlet ducts is much lower than it was through the original louvers, screens and inlet ducts [ ]^{a,c}. As in the previous design, air exiting these ducts enters a common plenum inside the shield building that transitions to the outer flow annulus described above. Some additional gratings have been added to this common plenum volume. All of these design changes are expected to increase the overall resistance of the PCS flow path.

The revised PCS air outlet design includes two heavy steel grates as shown in Figure 3-3; one is located at the chimney inlet and the other at the chimney outlet. These grates protect the containment shell from external hazards. The flow area through the grates is lower than the original design without grates [ ]^{a,c}. The addition of these grates is expected to increase the overall resistance of the PCS flow path.

Figure 3-4 shows the roof, inlet louver, inlet, and chimney exit elevations of the enhanced shield building design.

The resistance to PCS air flow is expected to increase due to the local reductions in the flow area at the inlet ducts and in the vicinity of the grates in the air outlet. The increased resistance and decreased density driving head due to the reduced chimney height will reduce the natural circulation flow rate through the PCS air flow path. The impact of the shield building design changes on the PIRT, scaling, and test results is described later in this report.

a,c

Figure 3-1: Enhanced AP1000 Shield Building Air Inlet Design

[ ]a,c

Figure 3-2: Enhanced AP1000 Shield Building Air Inlet Duct Layout

[ ]a,c

Figure 3-3: Enhanced AP1000 Shield Building Air Outlet Grating

a,c

Figure 3-4: Enhanced AP1000 Shield Building Elevation View

4.0 Impact of the PCS Air Inlet/Outlet Design Changes on the PIRT Results

The AP1000 containment phenomena identification and ranking table (PIRT) for limiting postulated design basis accidents (Loss-of-Coolant (LOCA) and Main Steam Line Break (MSLB)) is documented in Reference 1. The AP1000 PIRT was developed from the AP600 containment PIRT (Reference 2) and was reviewed by several Westinghouse internal experts and industry experts including:

- Dr. S. G. Bankoff, Dept. of Chemical Eng., Northwestern University
- Dr. L. E. Hochreiter, Dept. of Mech. and Nuclear Eng., Penn State University
- Dr. P. F. Peterson, Dept. of Nuclear Eng., University of California

The figure of merit for the PIRT is containment pressure. That is, all plausible phenomena are ranked (High, Medium, or Low) with respect to their relative influence on the figure of merit, in this case, containment pressure.

The high-ranked PIRT phenomena are of most importance with respect to the containment test database and code validation. For purposes of model or code development, all high and medium ranked PIRT phenomena are included in AP1000 containment modeling.

The high-ranked (most important) PIRT phenomena for AP1000 LOCA or MSLB in containment are summarized as follows:

- Break-related phenomena (i.e. mass, energy, and momentum).
- Containment volume compliance, circulation, and stratification.
- Heat capacity of internal heat sinks and containment shell.
- Condensation inside containment on internal structures and containment shell.
- Conduction associated with internal heat sinks and through the containment shell.
- Evaporation from the containment shell liquid film to the passive containment cooling system (PCS) annulus riser.
- PCS cooling water flow rate and film stability/coverage.

The revised AP1000 shield building design changes that could have a potential impact on AP1000 containment pressure response are:

- An expected increase in the hydraulic resistance at the inlet and outlet of the PCS air flow path
- The reduction in the density driving head for natural circulation due to the decrease in chimney height (height decrease of 5 feet).

A re-examination of the containment phenomena in light of these PCS air flow path design changes indicates that, while they may have some impact on the containment response, the nature of these PCS design changes does not introduce any new phenomena into the AP1000 containment PIRT. The PCS performance with respect to containment pressure response is still dominated by LOCA or MSLB energy transfer from the containment shell via condensation on the inside surface of the containment shell, conduction through the shell, and evaporation of the water film from the outer surface of the containment shell into the airflow circulating through the annulus and out the chimney.

The next step is to assess whether or not the ranking of AP1000 containment PIRT phenomena warrants an upgrade to a higher ranking. The PCS air flow path design changes directly impact the natural circulation flow rate due to the increased hydraulic resistances and buoyancy related change associated with the reduced chimney height. A change in the PCS natural circulation flow rate could influence important phenomena such as convection and evaporation from the PCS water film to the annular riser. The PCS water flow rate, film stability/coverage, condensation, and conduction associated with the containment shell phenomena are also coupled to PCS performance; however, these phenomena are already high ranked, and as such should remain high ranked in the AP1000 PIRT. The PCS design changes have no impact on other important containment phenomena such as the break-related phenomena, containment volume compliance, internal circulation, and conduction or heat capacity associated with internal heat sinks. These high-ranked phenomena are not strongly coupled to the PCS natural circulation phenomena and hence their rankings will remain unchanged. Therefore, none of the containment PIRT phenomena rankings need to be revised due to the PCS air flow path design changes

5.0 Impact of the PCS Air Inlet/Outlet Design Changes on the Scaling Results

The key scaling groups related to heat transfer in the annulus downcomer, riser, and chimney regions, as documented in Reference 4, are reassessed to determine the potential impact of the PCS air flow path design changes. The impact of the design changes on the operating range of the AP1000 heat and mass transfer correlations is shown in Table 5-1 below. The percent differences of the key scaling groups are small and negative indicating the PCS air flow path design changes are expected to slightly reduce the AP1000 operating range. Therefore, the range of test data that was used to validate the AP1000 PCS heat and mass transfer correlations remains acceptable.

Table 5-1
Operating Range Comparison for AP600 and AP1000 Heat and Mass Transfer Parameters Including the Percent Difference for the AP1000 Shield Building with Design Changes

Heat Transfer Correlation	Parameter	Composite of Test Data	AP600 Range	AP1000 Range	**Percent Difference, Enhanced AP1000 Shield Building Relative to Original**
Internal Free Convection: $h = 0.13\ k/(v^2/g)^{1/3}\ (\Delta\rho/\rho)^{1/3}\ Pr^{1/3}$	$\Delta\rho/\rho$	0.08 to 0.55	<0.40	<0.42	N/A
	Pr	0.72 to 0.90	0.72 to 0.90	0.72 to 0.90	N/A
	Sc	~0.52	~0.52	~0.52	N/A
External Mixed Convection: $Nu_{force} = 0.023\ Re_d^{0.8}\ Pr^{1/3}$ $Nu_{free} = 0.13\ (Gr_d\ Pr)^{1/3}$ For Opposed Mixed Convection: $Nu_{mix} = (Nu_{force}^3 + Nu_{free}^3)^{1/3}$ For Assisted Mixed Convection: $Nu_{mix} = Max\{(Nu_{free}^3 - Nu_{force}^3)^{1/3}, Nu_{free}, 0.75*Nu_{force}\}$	Re_d Annulus	<120000 evap. <500000 dry	<189000	<210000	**-15.0%**
	Re_d Downcomer		<151000	<190000	**-7.0%**
	Re_d Chimney		<1400000	<1800000	**-13.0%**
	Gr_d Annulus	$<7.0x10^{10}$evap. $<1.0x10^{11}$ dry	$<1.2 \times 10^9$	$<1.5 \times 10^9$	**-4.7%**
	Gr_d Downcomer		$<6.2 \times 10^9$	$<2.1 \times 10^{10}$	
	Gr_d Chimney		$<2.1 \times 10^{12}$	$<8.0 \times 10^{12}$	**2.9%**
	Pr	~0.72	~0.72	~0.72	
	Sc	~0.52	~0.52	~0.52	
Liquid Film Heat Transfer: $Nu_{turb} = 0.0038\ Re^{0.4}\ Pr^{0.65}$ $Nu_{wavy\ laminar} = 0.822\ Re^{-0.22}$	Re	20000	<3200	<3500	
	Pr	1.77 to 5.9	1.5 to 3.0	1.5 to 3.0	

6.0 Impact of the PCS Air Inlet/Outlet Design Changes on the Test Results

A number of tests were performed to support the AP1000 Passive Containment Cooling System (PCS) design and to provide data for computer code validation. These include:

1. Simple tests to determine the wetting characteristics of the coating used on the containment vessel inside and outside steel surfaces.
2. Condensation tests to determine steam condensation rates from air/steam mixtures on the inside surfaces of the containment vessel.
3. Heat transfer tests to determine heat and mass transfer coefficients on the outside of the containment shell with both water evaporation and air-only cooling over the full range of expected conditions.
4. Integral heat transfer tests (steam/air filled steel tanks with simulation of both inside and outside surface heat transfer) at two different scales to determine the heat removal characteristics of the PCS at various steady state conditions.
5. PCS air flow path characterization tests to determine the overall air flow path resistance and the pressure drop characteristics of the air flow path through the shield building.
6. Wind tunnel tests to confirm that wind effects aid the PCS air flow rate, and thus, establish that simple natural circulation during calm conditions is the bounding minimum basis for PCS air flow through the shield building. These tests included establishing the location of the air inlets, determining the effect of wind speed and direction, verifying that the wind effects from surrounding buildings and structures do not impede air flow, and establishing bounding geographic limitations on the plant site.
7. Water distribution tests to demonstrate, at full scale, the effectiveness of the PCS water distribution devices in establishing the required water film coverage on the outer surface of the steel containment. This test included simulating the limiting surface shape and plate-to-plate alignments allowed by the ASME code.

The applicability of each of these tests will be discussed relative to the changes in the shield building design.

<u>Heat and Mass Transfer tests</u>

These tests consisted of laboratory scale tests of steam condensation, evaporation, and free and forced convection on a heated steel plate (Reference 3). The heat and mass transfer correlations that were selected to be used in the WGOTHIC containment evaluation model were qualified using results from these tests. These heat transfer mechanisms do not change for the enhanced shield building design, and the range of test data still covers the expected operating range with the enhanced shield building design. Therefore, these tests remain applicable and no new testing is required.

<u>Wind Tunnel Tests</u>

The AP1000 Passive Containment Cooling System (PCS), as described in Section 2.0, utilizes the natural circulation of air upward along the outside surface of the steel containment vessel (SCV) to remove heat from inside the containment. Thus the SCV steel shell acts as the heat transfer surface and the air flow is employed either to assist in the evaporation of water from the SCV outer surface or to directly cool the SCV shell by convective heat removal.

A criterion in the design of the PCS was to have a shield building configuration and air flow path through the shield building, such that the wind would aid the natural circulation of PCS cooling air. This would result in being able to assume that no wind was present, and that only the buoyancy of the heated air or air/water vapor mixture need be considered in the analysis of the AP1000 containment pressure following postulated design basis or beyond design basis events. This goal was accomplished and documented in a series of wind tunnel tests performed at the University of Western Ontario's Boundary Layer Wind Tunnel Laboratory, as summarized below.

- Phase I Wind Tunnel Testing for the Westinghouse AP600 Reactor, April 1992 (Reference WCAP-13294) [Reference 5].
- Phase II Wind Tunnel Testing for the Westinghouse AP600 Reactor, August 1992 (Reference WCAP-13323) [Reference 6].
- Phase IVa Wind Tunnel Testing for the Westinghouse AP600 Reactor, May 1994 (Reference WCAP-14068) [Reference 7].
- Phase IVa Wind Tunnel Testing for the Westinghouse AP600 Reactor, Supplemental Report, September 1994 (Reference WCAP-14169) [Reference 8].
- Phase IVb Wind Tunnel Testing for the Westinghouse AP600 Reactor, July 1994 (Reference WCAP-14091) [Reference 9].

These tests and the test results, as related to the revised AP1000 shield building configuration, are discussed below.

A 1/96.67-scale model of the AP600 plant, including the adjacent buildings and cooling tower structure, was constructed and instrumented with pressure taps. The model was placed in the boundary layer wind tunnel which reproduces the wind gradient versus height and wind turbulences that occur in nature. A photograph of the wind tunnel test facility and containment model is shown in Figure 6-1.

The tests were performed in phases to examine different aspects of the design and to enable modifications to the subsequent test conditions and test articles to suit the test objectives. The Phase I testing included test runs with changes to the plant model that are pertinent to the revised AP1000 shield building. These changes, which are listed below, did not violate the design criterion that the wind would always aid natural circulation induced PCS cooling air flow.

- The air exhaust/PCS water storage tank structure was raised and lowered [ ]^{a,c} relative to the base case air inlet elevation. The tested air outlet elevations were [ ]^{a,c} above outside edge of the shield building roof [ ]^{a,b,c}. The revised AP1000 shield building exhaust height is 59'-6" and is within the range tested.
- Two air exhaust/PCS water storage tank structure diameters were tested, [ ]^{a,b,c}. Note the larger diameter air exhaust structure was used for all subsequent test phases of the wind tunnel testing. The AP1000 air exhaust structure diameter is 89 ft, which closely corresponds to the larger tested diameter.
- The shield building was raised or lowered [ ]^{a,c} relative to the turbine building roof elevation base case. The tested elevations had the shield building roof outside edge [ ]^{a,c} above the turbine building roof elevation, and]^{a,c} below the turbine roof elevation. (It is noted that the turbine building is the highest and largest building adjacent to the shield building.) [ ]^{a,b,c} The revised AP1000 shield building roof outside edge is 23 ft. above the turbine building roof which is within the height difference tested.
- A shield building with a roof over-hang and air inlet openings [ ]^{a,c} below the top edge of the over-hang [ ]^{a,c} was tested, and a shield building with a roof with no over-hang [ ]^{a,c} was tested.

Note that, the test with the over-hang included the air inlets behind the over-hanging portion of the roof. [ ]a,b,c The revised AP1000 shield building roof line and air inlet location 8'- 7" below the top edge of the over-hang are very similar to the Phase-I wind tunnel test article with the shield building roof over-hang.

- Test runs were also made with the air exhaust/PCS water storage tank structure covered with an external missile shield. This design feature was not incorporated in the AP600 or AP1000 designs but it is noted only to illustrate that the effect of even this dramatic change in the air exhaust structure did not prevent the wind from aiding the PCS air flow.

The wind tunnel tests included variations of the shield building design features that either encompass or very closely simulate, the revisions made to the AP1000 shield building. These tests confirmed that modifying the shield building features; such as including a protruding roof over-hang, lowering the air inlets, varying shield building and exhaust structure height, and increasing exhaust structure diameter, would meet the criteria that wind would always aid the natural circulation of PCS cooling air. Figure 6-2 displays an approximate envelope drawing that conveys the wind tunnel scaled facility as compared to the enhanced shield building design. The scaled wind tunnel model was taken from Reference 6. [

]a,c

Water Distribution Tests

The water distribution tests (Reference 10) were conducted to determine, at full scale, the effectiveness of the PCS water distribution devices in establishing the required water film coverage on the outer surface of the steel containment. These tests included simulating the limiting surface shape and plate-to-plate alignments allowed by the ASME code. Since there are no changes to this portion of the PCS, the testing that was done to support the WGOTHIC AP1000 evaluation model is still valid for the revised AP1000 shield building design.

Integral Tests of the PCS

The integral tests were conducted to determine the overall heat transfer characteristics and water film behavior using a simulated containment vessel over the full range of expected accident conditions. The tests were performed at two scales.

The Small Scale Test (SST) Facility (Reference 11) was a [ ]a,c pressure vessel into which steam was injected uniformly along the length. A photograph of the SST facility is shown in Figure 6-3. The cooling annulus around the vessel was formed by a Plexiglas cylinder with air inlets at the bottom and a fan at the top to achieve prototypic maximum air velocities.

The Large Scale Test (LST) Facility (Reference 12) was a 1/8th scale of the AP600 containment vessel and therefore had a more prototypic height-to-diameter ratio than the SST. A photograph of the LST facility is shown in Figure 6-4. This facility was used to study the distribution of steam and non-condensable gases inside the containment vessel, in addition to the overall heat transfer from inside the vessel to the outside environment. Steam was introduced into the interior of the vessel at several locations via simulated internal structural compartments. The LST also had air inlets at the bottom of an annulus formed by the containment vessel and a Plexiglas cylinder, and a fan at the top to enable the full range of air velocities.

Both the SST and LST facilities had a water supply and water distribution devices at the top of the vessel to simulate the PCS water applied during accident scenarios.

These tests did not model the PCS air flow path explicitly, but the range of air velocities simulated in the tests envelope the range of air velocities that could occur in the revised AP1000 shield building design during accident conditions. Therefore, the results of these tests remain applicable to the revised AP1000 shield building design.

Air Flow Path Characterization Tests

These tests consisted of a 1/6 scale-model section of the PCS flow path. A photograph of the original annulus pressure drop test apparatus is shown in Figure 6-5. Pressure difference measurements were taken and used to develop loss coefficients that were incorporated into the WGOTHIC AP1000 evaluation model.

The changes to the enhanced shield building design are expected to increase the pressure drop through the air inlets and through the air outlet region above the containment dome. Since the Air Flow Path Characterization Tests were specific to the previous shield building design, they are not wholly applicable to the new design and a new set of tests must be performed.

A drawing of the new annulus pressure drop test apparatus is shown in Figure 6-6. The Reduced-scale Air Flow Test (RAFT) facility is a 1/6 scale-model of a [ ][a,c] section of the PCS flow path from the inlets at the top of the cylindrical shield building, through the shield building downcomer region between the air flow baffle and the shield building inside wall, around the 180° turn at the operating deck elevation, into the entrance and through the annulus between the air flow baffle and the steel containment shell, and out the air exhaust opening at the top-center of the shield building. A detailed description of the scaling analysis, test facility, instrumentation, test matrix/procedures, and test results is provided in Reference 13.

The density, velocity and pressure difference measurements from the annulus pressure drop tests are used to determine the local annulus loss coefficients. The combined form and friction loss coefficients are calculated using the equation below:

$$(K + fL/D) = 2*\Delta P/(\rho v^2)$$

where K is the form loss coefficient, f is the Moody friction factor, L is the friction length, D is the hydraulic diameter, ΔP is the measured pressure drop, ρ is the measured air density, and v is the measured air velocity. Table 6-1 provides a comparison of the local annulus pressure drop values for the enhanced shield building design with the values from the original shield building design (Reference 15). As expected, the measured pressure drops through the revised PCS air inlet and outlet regions are higher. The losses assumed in safety analyses are shown to be conservatively high by the scale testing of Reference 13 in Table 6-1.

Table 6-1: Comparison of the Local Annulus Pressure Drop Values

a,c

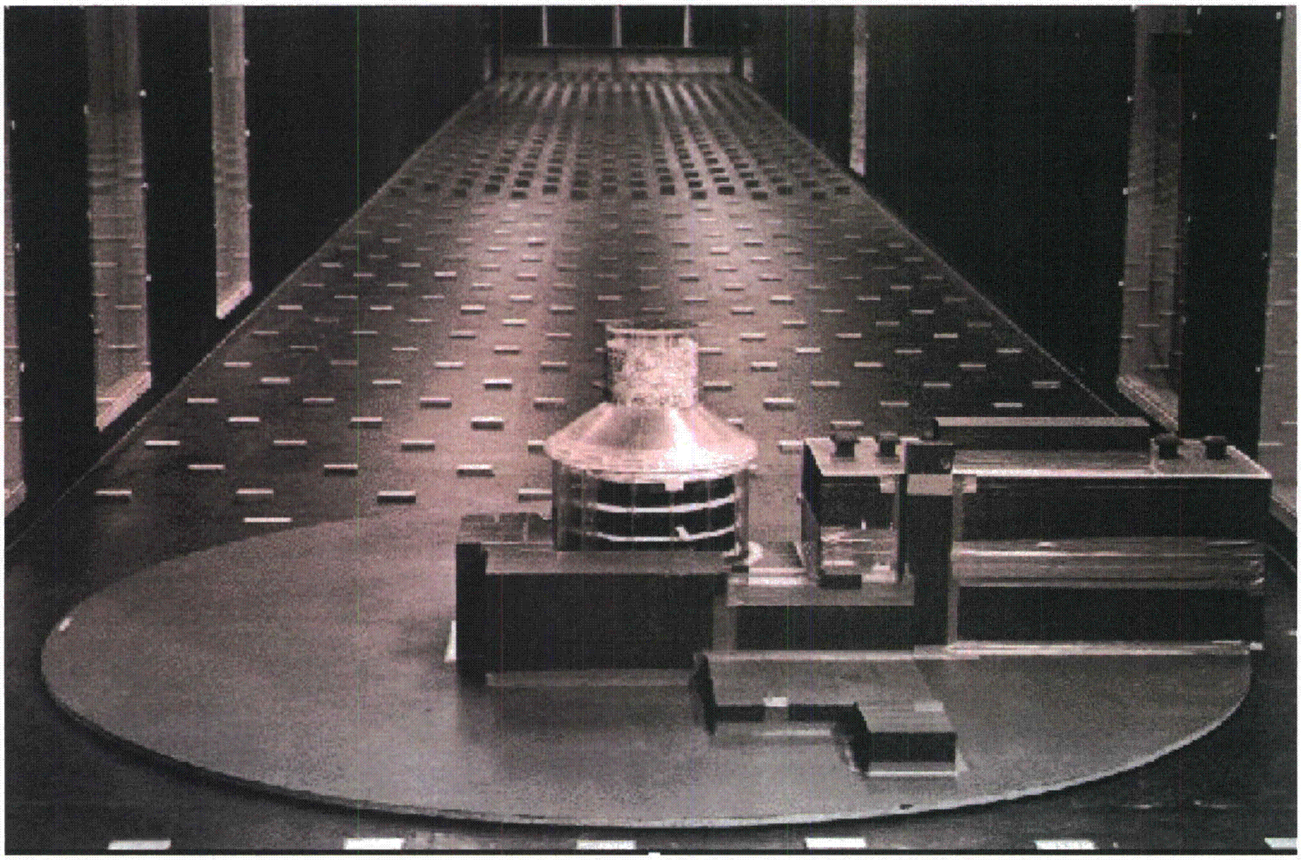


Figure 6-1: Wind Tunnel Test Facility

[ ]a,c

Figure 6-2: Wind Tunnel model comparison with Enhanced Shield Building Design

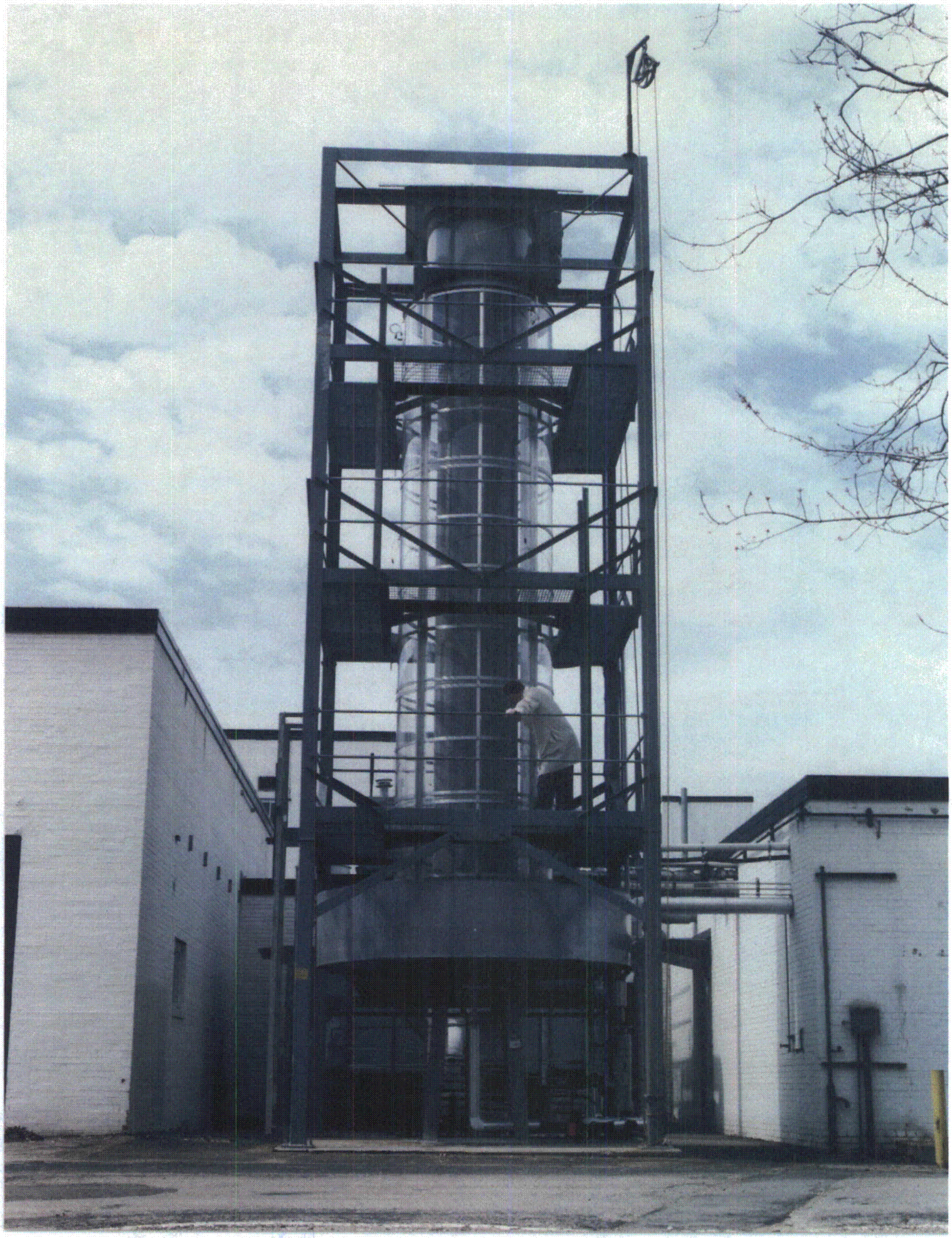


Figure 6-3: Small Scale Test Facility

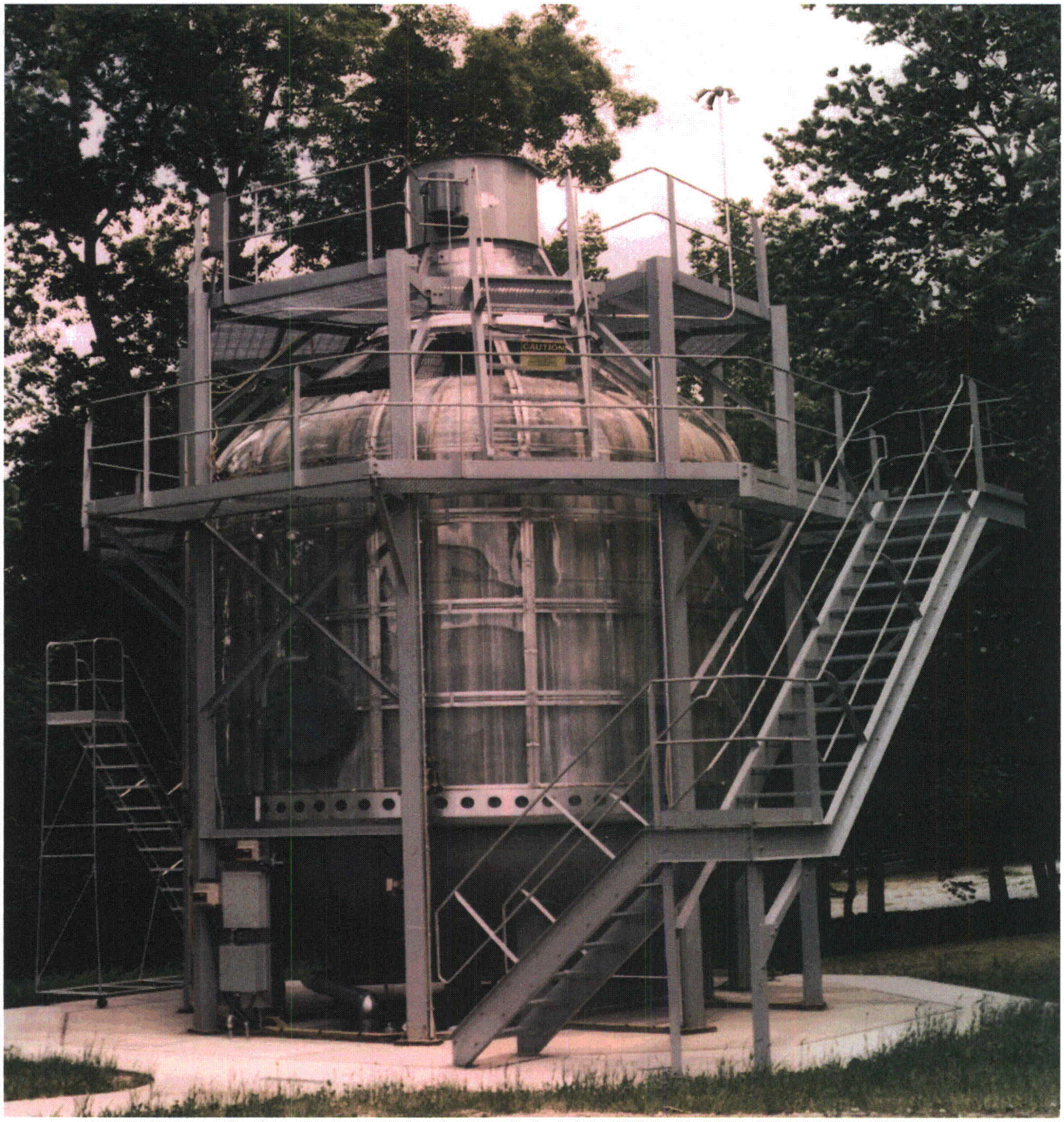


Figure 6-4: Large Scale Test Facility

Figure 6-5: Original Annulus Pressure Drop Test Apparatus

a,c

Figure 6-6: New Annulus Pressure Drop Test Apparatus

7.0 Description of the Changes to the WGOTHIC AP1000 Containment Evaluation Model

The WGOTHIC computer code was developed during the AP600 project to perform the containment design basis accident analyses. GOTHIC version 4.0 (Reference 14) was modified to include models for the PCS heat and mass transfer; the new code version was called WGOTHIC 4.2a. The WGOTHIC code and models have been extensively verified and validated using test data generated during the AP600 and AP1000 design certification effort.

The WGOTHIC AP1000 containment evaluation model is described in Reference 15. The WGOTHIC AP1000 containment model consists of discrete control volumes that represent various compartments and open spaces within the containment shell. The volume, hydraulic diameter, pool area, elevation and height are the required input values for each control volume.

The control volumes are connected to each other using flow paths. The inlet/outlet elevations, flow area, hydraulic diameter, inertia length, friction length and form loss coefficients are the required input values for each flow path.

Thermal conductors may be located inside or between the control volumes. Thermal conductors represent passive heat sinks such as equipment and structures inside the containment. The heat transfer area, initial temperature, material properties (thermal conductivity, density, and specific heat), and material layer thicknesses are the required input values for each thermal conductor.

The initial conditions for the control volumes and heat sinks are biased to maximize the calculated containment pressure. With exception of the volume representing the IRWST, the containment volumes are assumed to initially be filled with dry (0% relative humidity) air at a temperature of 120 F and a pressure of 1.0 psig.

The PCS annulus is also constructed of control volumes, flow paths and thermal conductors. The PCS annulus consists of [ ][a,c] control volumes and [ ][a,c] flow paths ranging from the air inlets to the air outlet. The thermal conductors representing the containment shell are connected to the control volumes inside the containment and to the PCS control volumes that make up the inner annulus. The thermal conductors representing the baffle are connected to the PCS control volumes in the inner annulus to the PCS control volumes in the outer annulus. The thermal conductors representing the shield building are connected to the PCS control volumes in the outer annulus and the control volume that represents the environment.

Heat and mass transfer from the containment to the PCS is calculated using models for condensation, conduction, evaporation, and convection. The heat and mass transfer correlations are bounded to minimize the effectiveness of the heat removal process. The radiation heat transfer from the shell to the baffle, from the baffle to the shield building, and from the shield building to the environment is also modeled.

The inlet and outlet of the PCS air flow path are connected to boundary conditions that specify the environmental air pressure, temperature, and relative humidity. The pressure boundary condition input values are also conservatively biased to minimize the effectiveness of the heat removal process.

Large pipe breaks are simulated by the release of mass and energy into a control volume using flow boundary conditions. These mass and energy releases are calculated using other codes and data tables are imported into WGOTHIC in the form of mass flow rate and enthalpy boundary conditions as a function of time.

The WGOTHIC AP1000 containment evaluation model input was modified to evaluate the impact of the PCS air inlet/outlet design changes on the results of the various safety analyses. Some of the control volume and flow path input values that represent the PCS annulus were changed. These input changes are described below.

Noding Structure Changes

The new AP1000 annulus noding structure is shown in Figure 7-1. [

]^{a,c}

Control Volume Changes

[

]^{a,c}

Flow Path Changes

[

]a,c

a,c

Figure 7-1: AP1000 Annulus Noding Diagram for Enhanced Shield Building Design

8.0 DBA Event Results

A large pipe break inside the containment is assumed to initiate a DBA event. This would include the main steam line break (MSLB) events and the large break loss of coolant accident (LOCA) events, such as a double-ended cold leg break. The large release of mass and energy into the containment results in a rapid increase in pressure. The pressure increase causes actuation of the PCS, which is initiated by opening the isolation valves at the bottom of the PCS water storage tank. Since there are three redundant and diverse valves that must fail to prevent water from being applied to the containment shell, the probability of not having PCS water is very low. The steel shell begins to slowly heat up due to steam condensation on the inside surface, and at first, evaporation from the outside surface is limited. Eventually, the shell does heat up, evaporation becomes more effective, and slows the pressurization of the containment atmosphere. The peak pressure for the event is reached and begins to decrease when the heat removal from the outside of the shell exceeds the rate of energy released into containment.

The peak pressure DBA is the DECLG LOCA. The LOCA event is characterized by two distinct phases; an initial blowdown period which continues until the reactor coolant system (RCS) pressure is nearly the same as the containment pressure, and a long term cooling period where the sensible heat of the RCS and the steam generators is released along with the reactor shutdown heat. This period can continue for several hours or days until the plant is recovered. During this time, it is assumed that only the passive safety-grade systems operate to mitigate the event. Evaporative cooling by the PCS is important for mitigating the long-term effects of the LOCA event.

A double-ended break of a main steam line results in high energy steam that pressurizes the containment. Unlike the LOCA event, there is no additional energy released to containment after the blowdown portion of the event is over. The peak pressure for this event is limited by the containment volume and by the absorption of energy by the passive heat sink structures inside the containment, including the steel shell. The PCS water starts to become effective at removing heat from the outside of the shell just about the same time that the blowdown ends.

Various conservative and bounding assumptions are made when performing the analysis of design basis events. Lower bounded heat and mass transfer correlations are used to minimize the heat removal from containment. The initial RCS conditions reflect upper bounded power operating conditions and the core decay heat release rate includes uncertainty. Finally, the containment initial conditions are biased to maximize the calculated pressurization.

The WGOTHIC evaluation model that was used in previous DCD analyses was modified to reflect the enhanced shield building design as described in Section 7.0. The design basis LOCA and MSLB event cases were run using this revised model to determine the impact of the enhanced shield building design on the calculated pressure and temperature response.

The calculated containment pressure, temperature, riser flow rate, and riser temperature results were compared. The comparisons for the double-ended cold leg guillotine (DECLG) LOCA containment response are shown in Figures 8-1 through 8-6. The pressure increases very rapidly due to the initial blowdown event. The pressure levels off as the internal passive heat sinks (including the containment shell) begin to condense steam. The pressure begins to increase again as the RCS and steam generator sensible heat is released to containment. The pressure eventually reaches a peak at about 1800 seconds after event initiation. At this time, evaporation of the PCS water effectively cools the containment shell and the pressure begins to slowly decrease.

Figures 8-1 through 8-4 show that change in the PCS air flow path due to the enhanced shield building design do not impact the calculated peak containment pressure and only have a small impact on the calculated containment peak temperature. Figures 8-3 and 8-4 show a slight variation in the calculated temperature after the peak values are reached. As expected, the calculated long-term containment temperature remains slightly higher for the rest of the transient. As shown in Figures 8-5 and 8-6, the shield building design change causes a reduction in the calculated riser velocity and a corresponding increase in the calculated riser outlet temperature.

The comparisons for a double-ended hot leg guillotine (DEHLG) LOCA containment response are shown in Figures 8-7 and 8-8. The enhanced shield building design has little or no impact on the calculated peak containment pressure and temperature for this short-term event.

The comparisons for the limiting steam line break containment response cases are shown in Figures 8-9 through 8-12. The enhanced shield building design also has little or no impact on the calculated steam line break containment pressure and temperature response.

The comparisons for the containment response following a postulated a loss of shutdown decay heat removal (LOSDHR) event with air only cooling are shown in Figures 8-13 and 8-14. An initial core decay heat rate of 6 MWt is assumed in this analysis. Figure 8-13 shows the enhanced shield building design causes a significant increase in the calculated peak containment pressure (about 15 psi). Figure 8-14 shows the decrease in the riser velocity is about 1.8 ft/sec with the new shield building design. For air only cooling, this reduction in the velocity causes a decrease in heat transfer from the shell. The 9 MWt core decay heat upper limit for air only cooling that is stated in the AP1000 Technical Specifications must either be reduced to a lower value or some PCS water cooling must be provided within 48 hours to keep the containment below the design pressure.

The modeling methods that are used to calculate the maximum negative containment shell differential pressure and the minimum containment backpressure are not impacted by the shield building design change. The velocity through the annulus for the maximum negative containment shell differential pressure case is set to an upper bounding value and the minimum containment backpressure model does not model the annulus, so the changes to the shield building air inlets do not affect the results for these analyses.

These results show that the enhanced shield building design has a negligible impact on the calculated peak pressure for the DBA events. The reduction in the PCS air flow rate due to the more restrictive air flow path reduces the convective heat transfer rate, but the evaporative heat transfer rate, which provides the majority of the heat removal from the containment shell, is not affected. References 16 and 17 contain the formal calculations and are the technical basis for the analyses depicted in Figures 8-1 through 8-14.

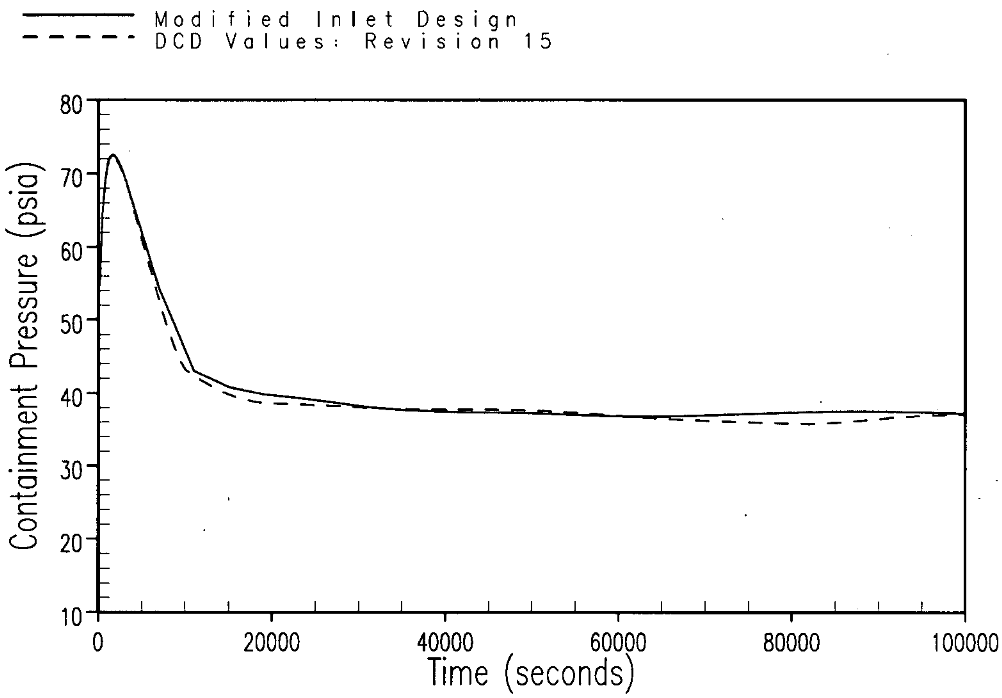


Figure 8-1: Long-term Containment Pressure Response Comparison for a DECLG LOCA

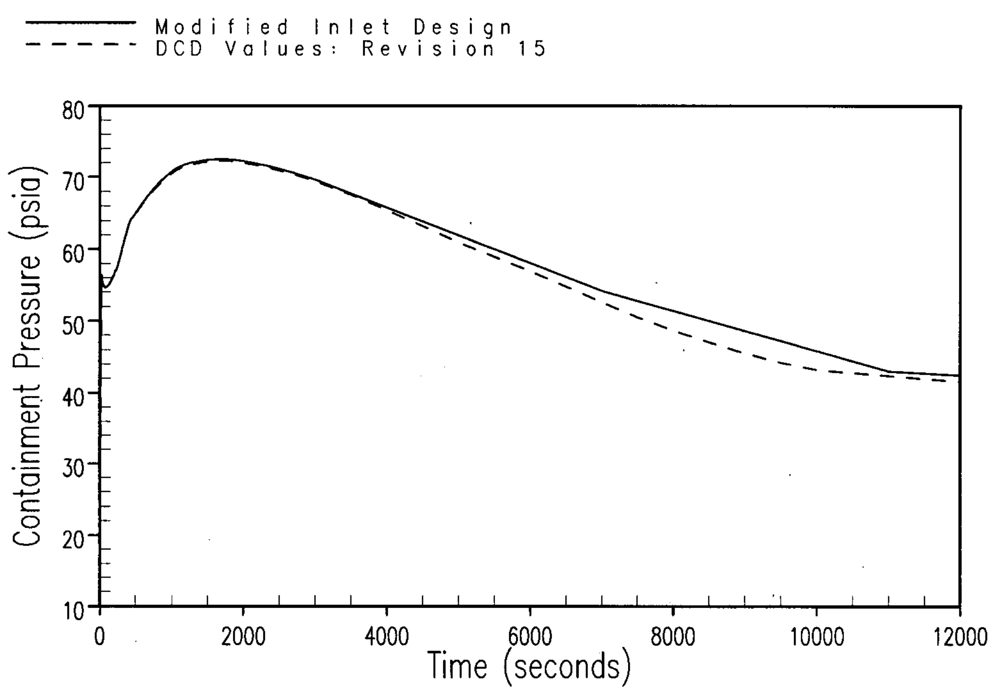


Figure 8-2: Intermediate-term Containment Pressure Response Comparison for a DECLG LOCA

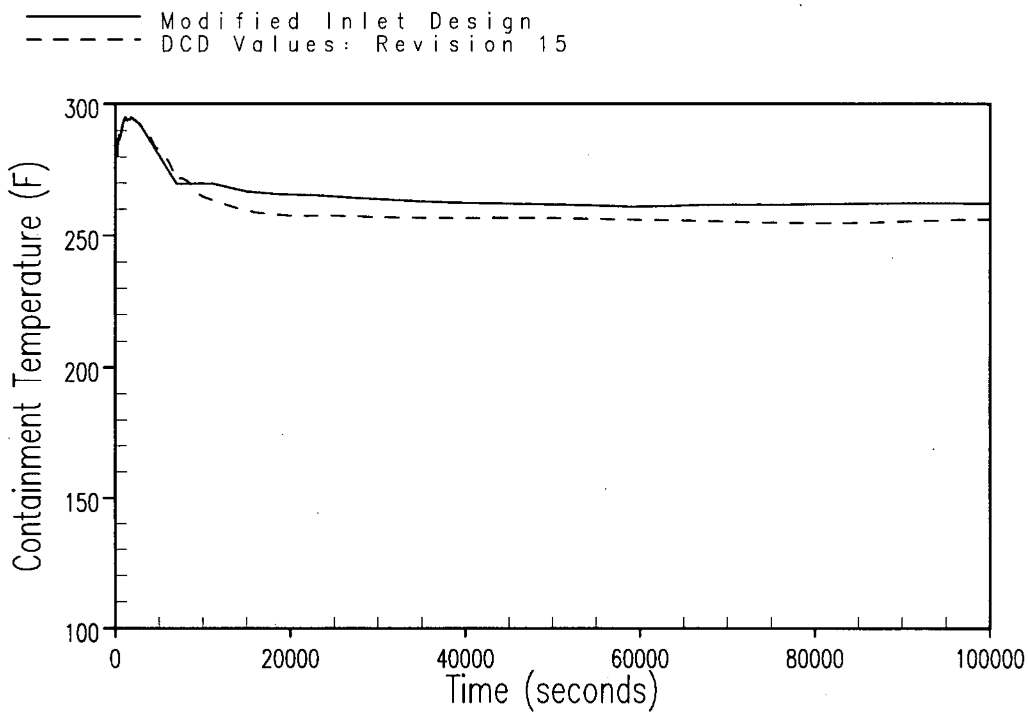


Figure 8-3: Long-term Containment Temperature Response Comparison for a DECLG LOCA

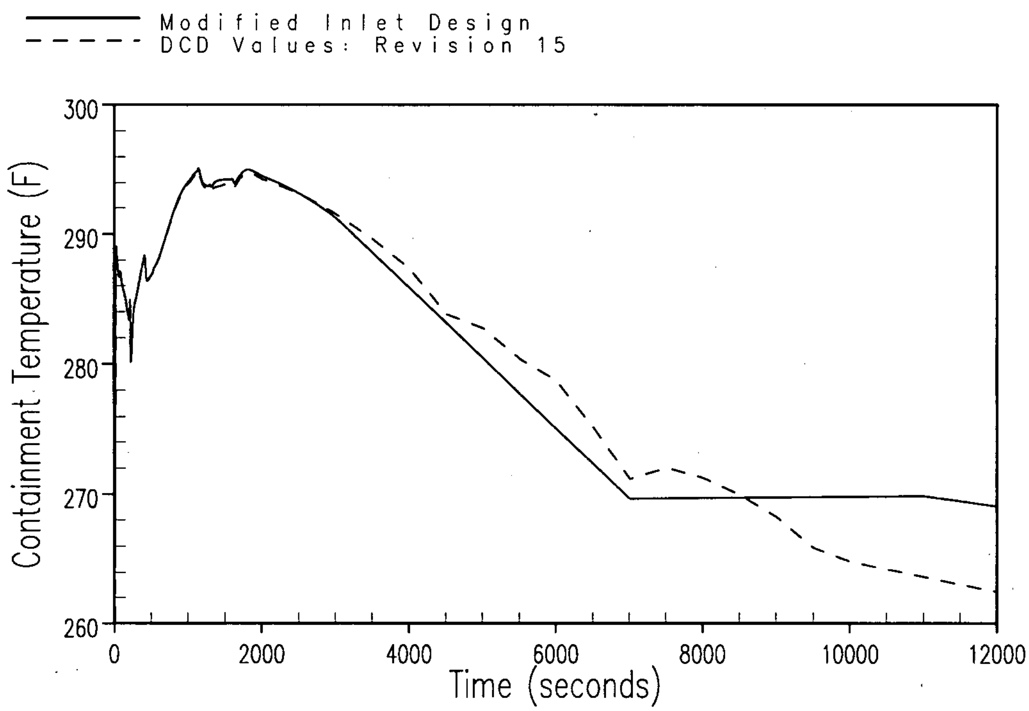


Figure 8-4: Intermediate-term Containment Temperature Response Comparison for a DECLG LOCA

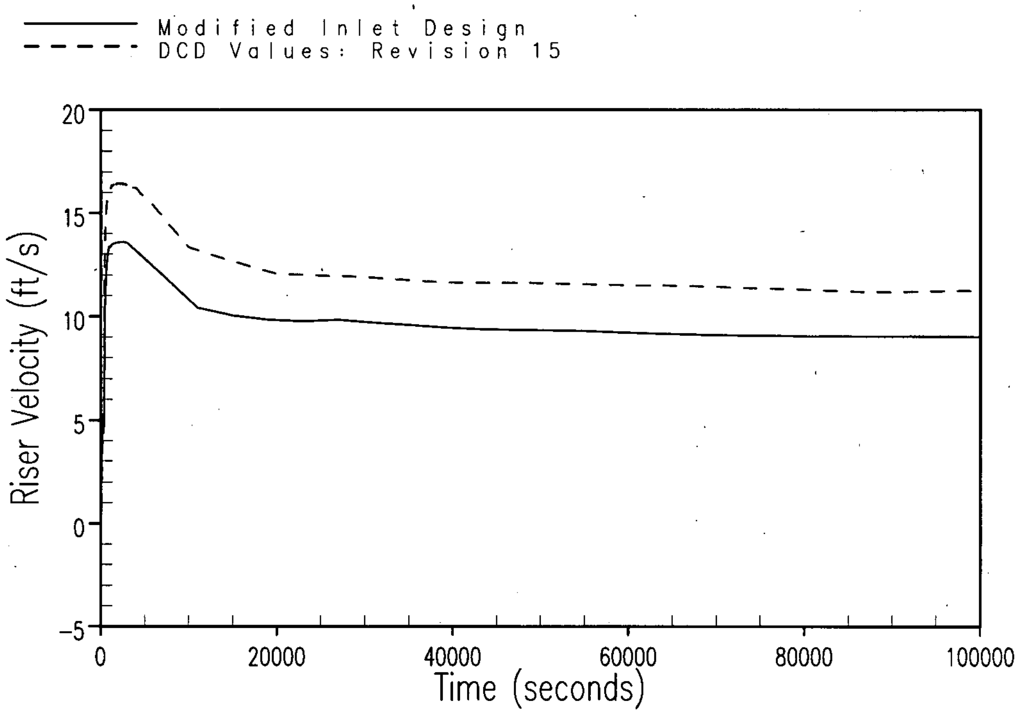


Figure 8-5: Riser Velocity Comparison for a DECLG LOCA

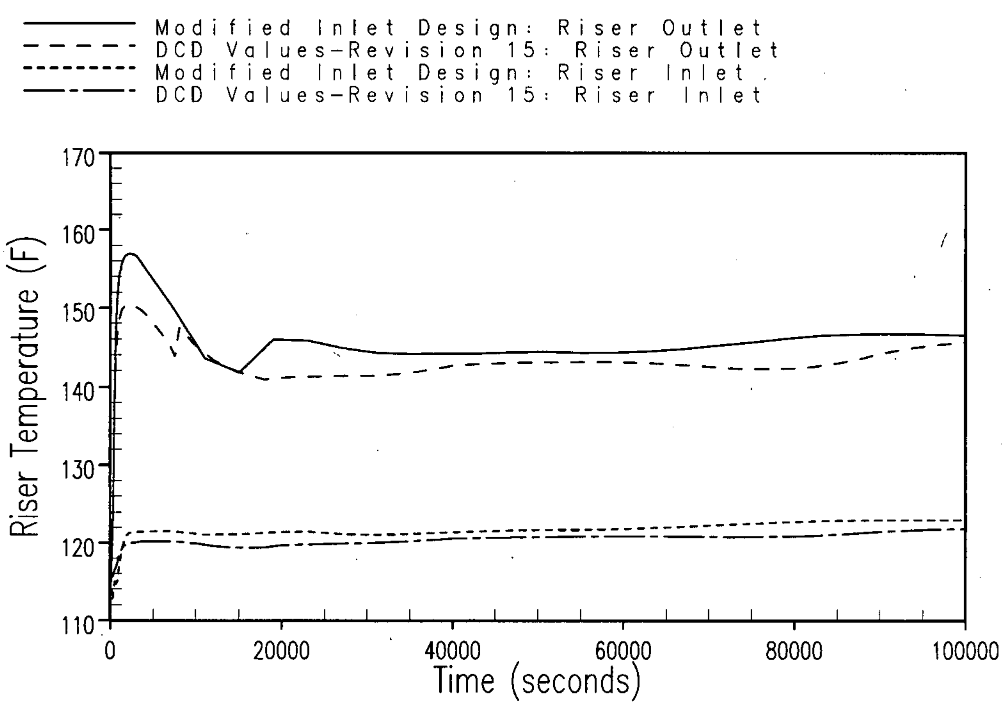


Figure 8-6: Riser Inlet and Outlet Temperature Comparisons for a DECLG LOCA

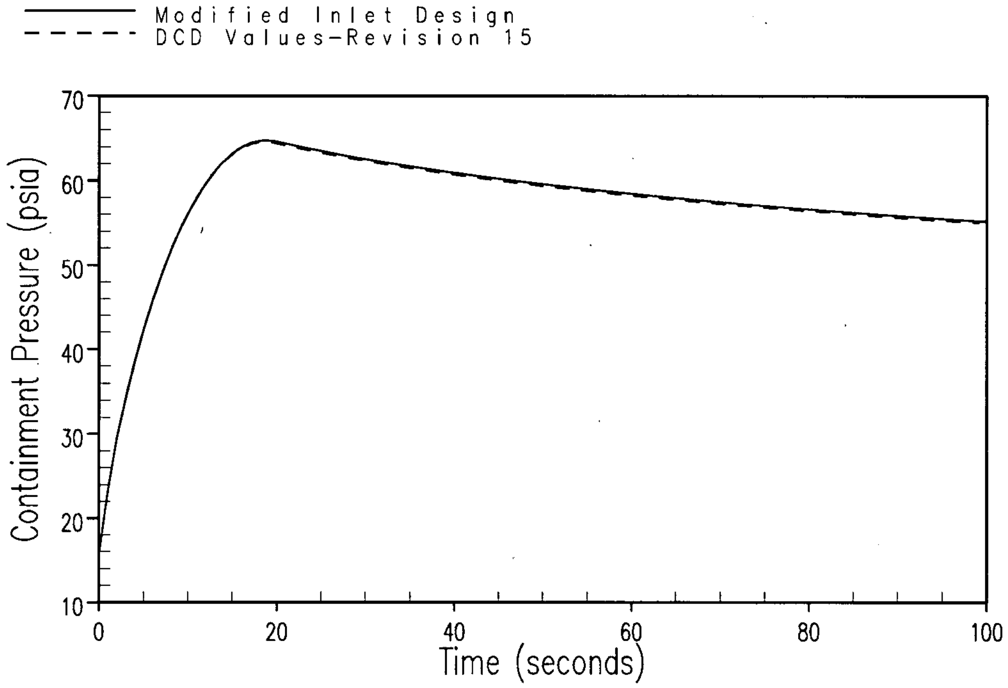


Figure 8-7: Containment Pressure Response Comparison for a DEHLG LOCA

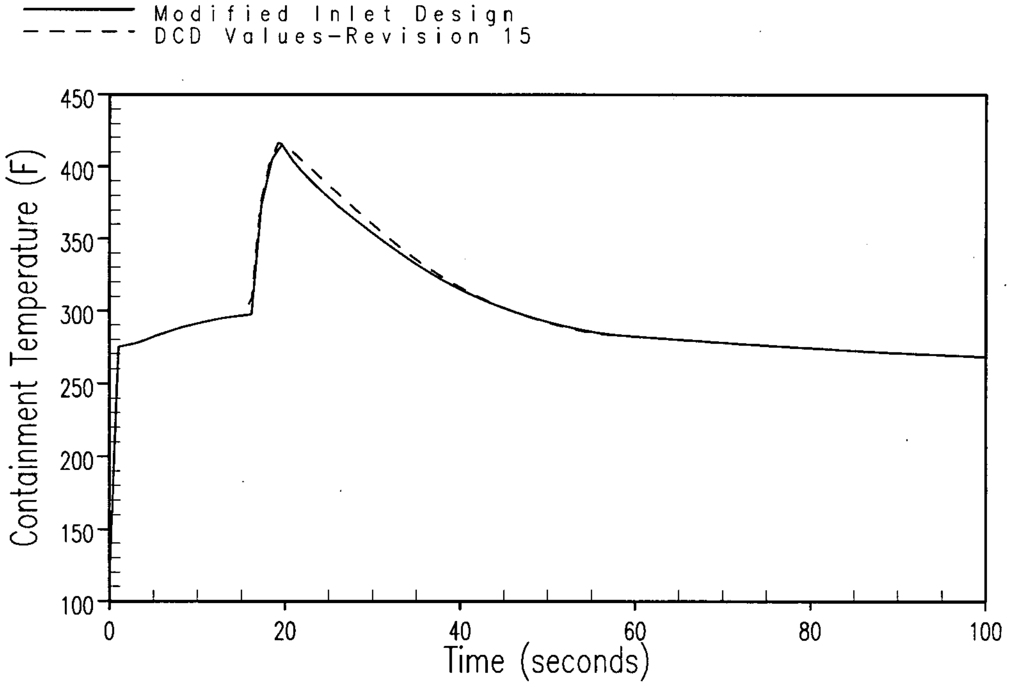


Figure 8-8: Containment Temperature Response Comparison for a DEHLG LOCA

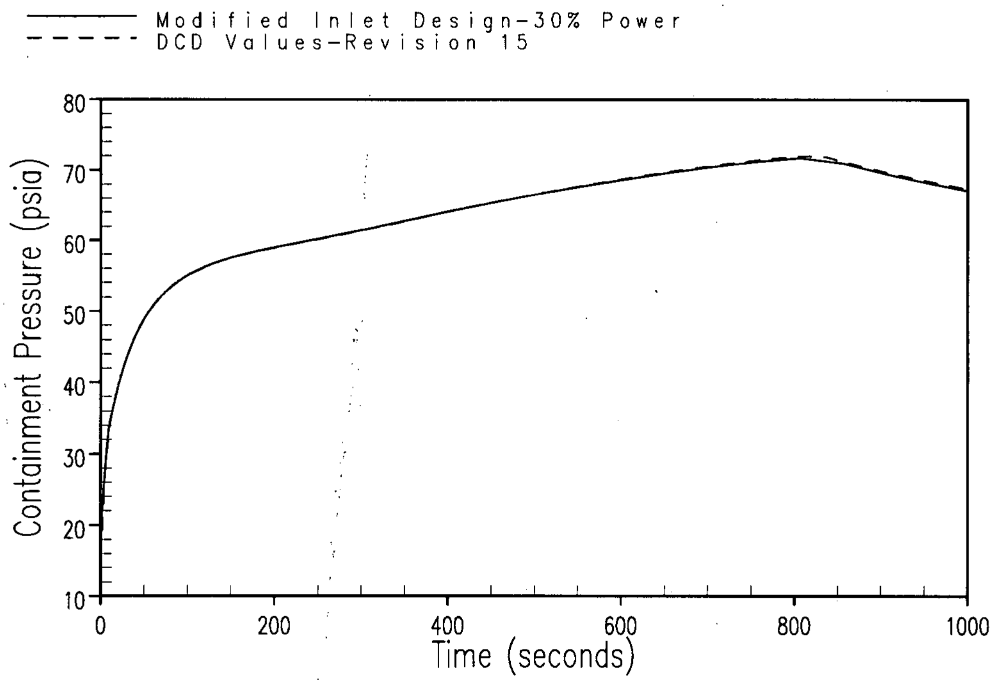


Figure 8-9: Containment Pressure Response Comparison for a SLB at 30% power

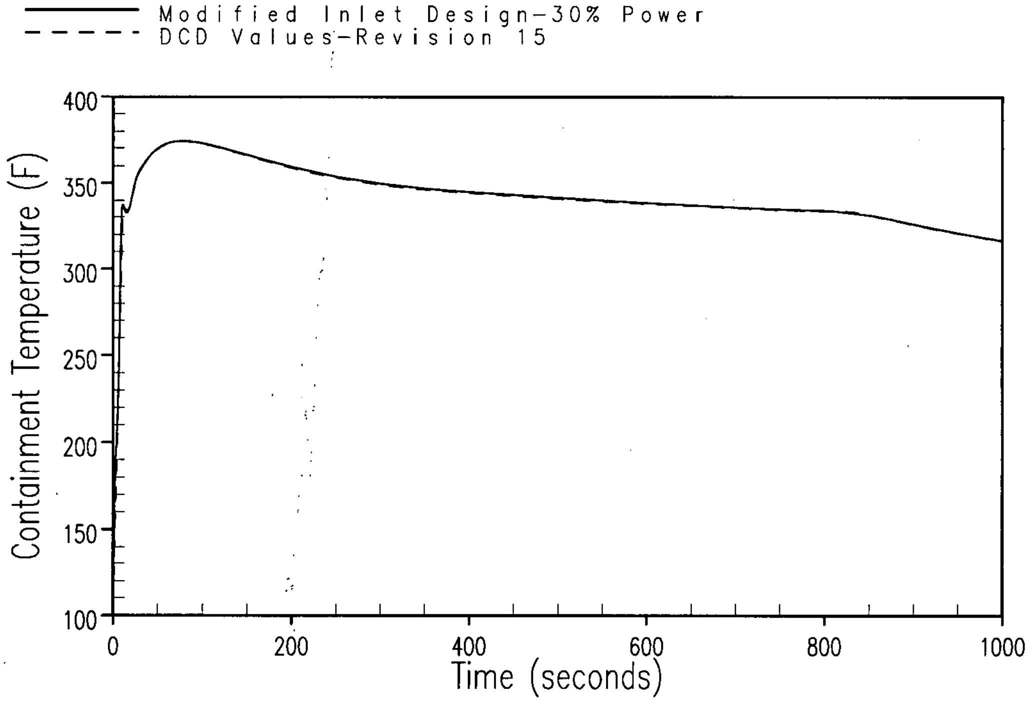


Figure 8-10: Containment Temperature Response Comparison for a SLB at 30% power

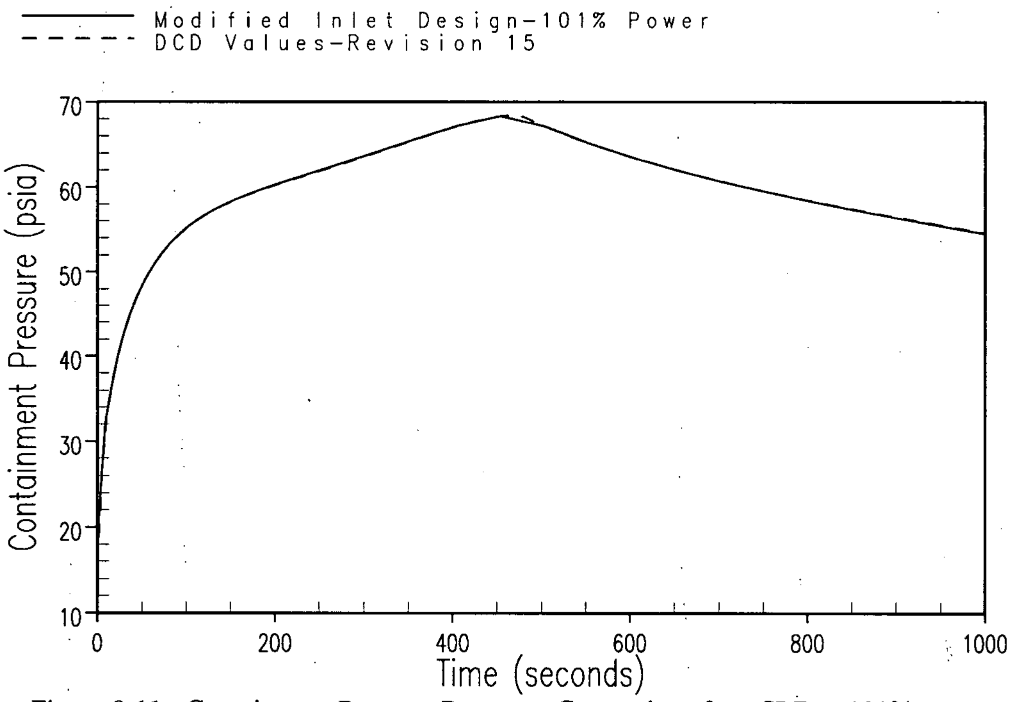


Figure 8-11: Containment Pressure Response Comparison for a SLB at 101% power

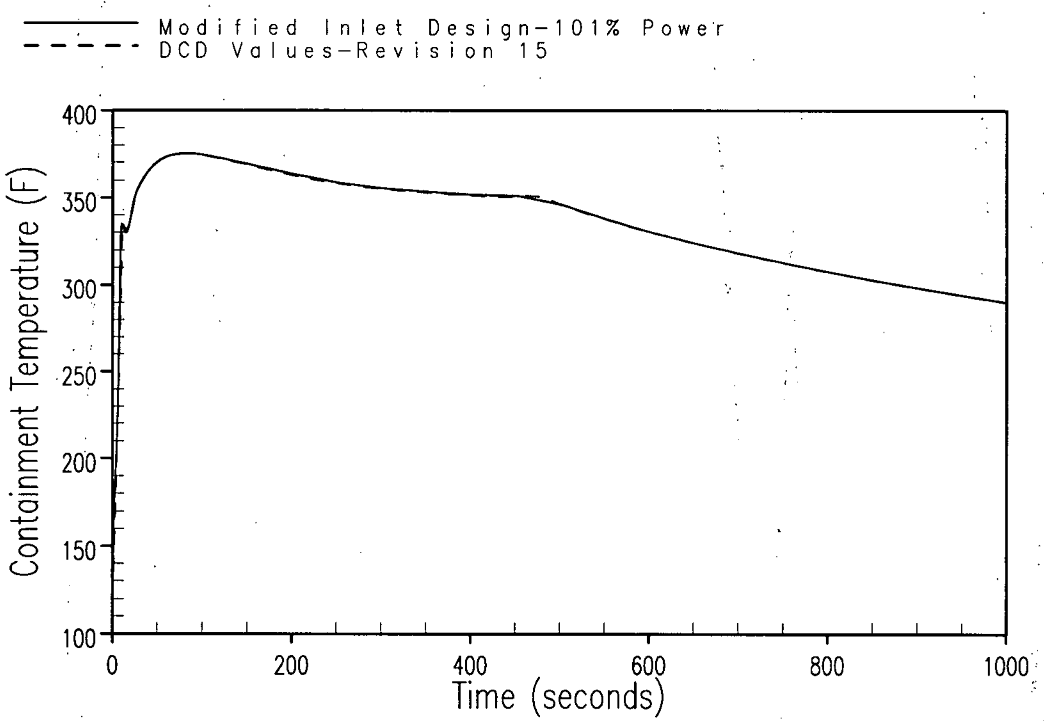


Figure 8-12: Containment Temperature Response Comparison for a SLB at 101% power.

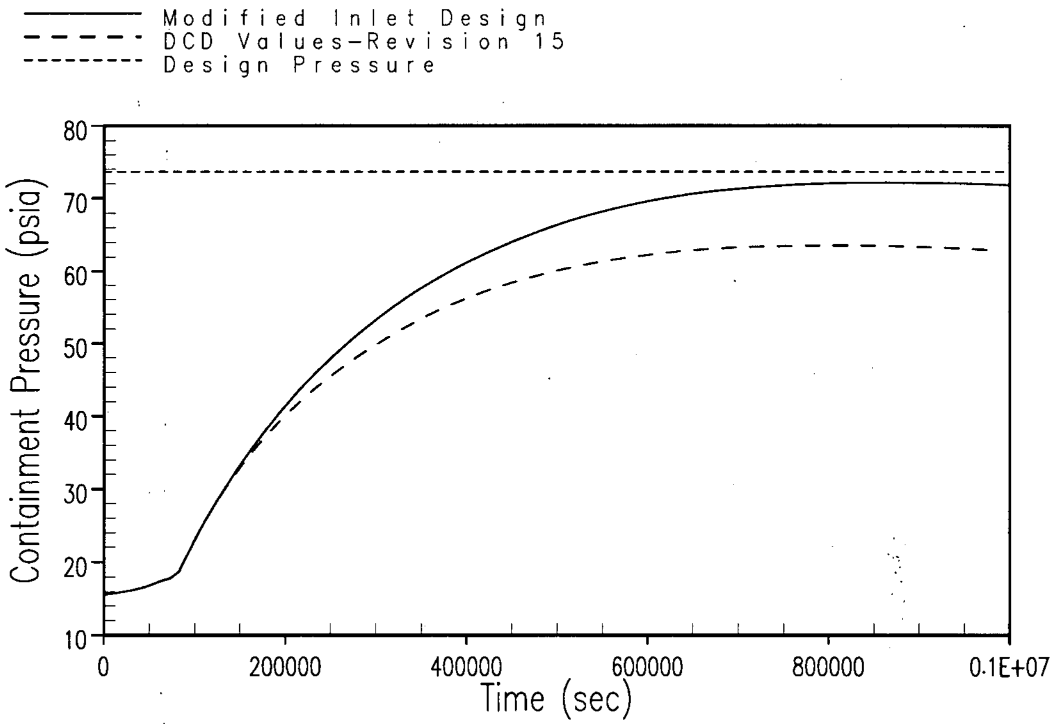


Figure 8-13: Containment Pressure Response Comparison for a LOSDHR with Air Only Cooling

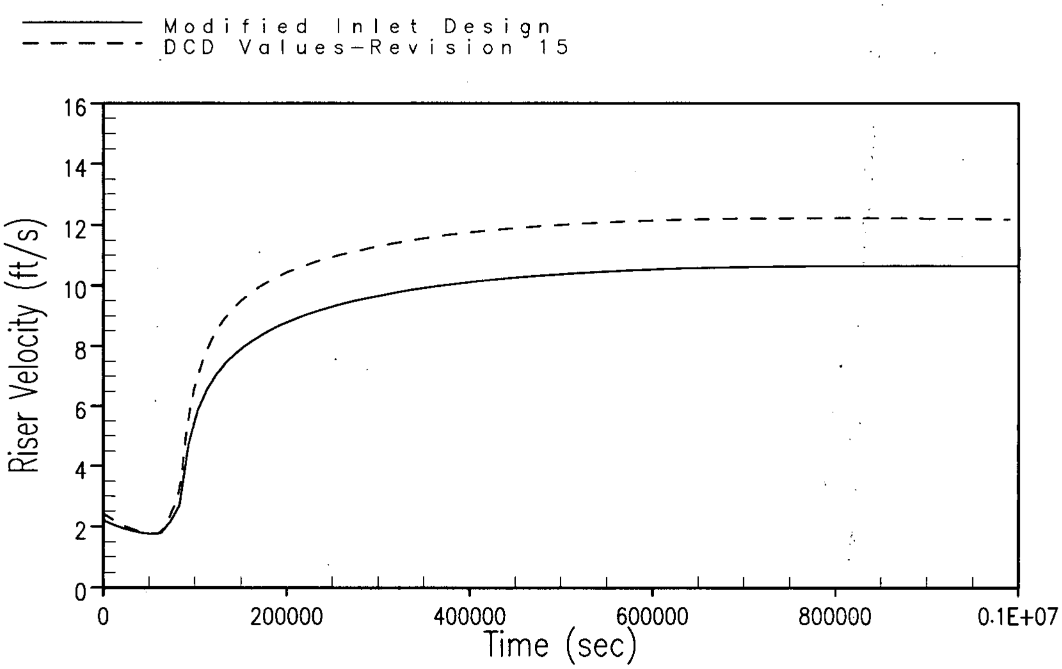


Figure 8-14: Riser Velocity Comparison for a LOSDHR with Air Only Cooling

9.0 Representative BDBA Event Results

The containment pressure limit for beyond design basis accident events is assumed to be the maximum pressure capacity limit from Section 3.8.2 of the AP1000 DCD (129 psig). This is well below the expected failure limit of the containment. Containment pressurization occurs over a long period of time. For this reason, the initiating event is relatively unimportant for beyond design basis accidents, as the integrated energy associated with an event such as blowdown is very small compared to the integrated reactor decay heat.

The initiating event for this comparison is a station blackout (SBO) coupled with a complete loss of PCS water. This is a highly unlikely occurrence since it requires the failure of three redundant and diverse active valves for the water to be lost. The probability of this occurring is calculated to be approximately 10^{-6}/yr.

Following the loss of offsite power, the reactor is shutdown and the passive core cooling system is actuated. For this non-LOCA event, the reactor decay heat plus the RCS sensible heat is deposited into the in-containment refueling water storage tank (IRWST) by the passive residual heat removal heat exchanger (PRHR HX). Within a few hours, the IRWST heats up and begins to boil. Some of the steam release from the IRWST causes the containment pressure to begin to slowly increase. Steam condenses on the passive heat sinks and the containment shell. Because of the long time period, the passive heat sinks become saturated, and the only heat removal mechanism is the heat transfer through the containment shell to the environment.

Due to the lack of water on the outside of the shell, the only mechanisms for heat removal to the environment are radiation and natural convection from the outside surface of the shell. The heated air in the PCS is less dense than the air outside, setting up a natural circulation flow through the annulus. The annulus flow rate is determined by a balance between the flow resistance of the PCS flow path and the density driving head generated by the temperature difference. The containment pressure will continue to increase until the convective and radiative heat removal rates from the shell match the decay heat rate.

The containment temperature and pressure are dependent on the magnitude of the heat transfer gradient to the ambient. The convective heat transfer is reduced by restricting the PCS air flow path, sothe shell temperature must increase to increase the heat transfer rate. This requires an increase in containment temperature and pressure to restore the gradient to a sufficient magnitude to remove the required amount of heat.

The analysis of beyond design basis events are generally performed using "best estimate" assumptions. [

]^{a,c}

The results of the BDBA case are shown in Figures 9-1 and 9-2. For this case, the increase in pressure occurs very slowly and no significant difference between the original and enhanced shield building designs becomes apparent until a long time after the event initiation. Figure 9-2 shows the difference between the calculated containment pressure responses for the two designs on an expanded scale. The calculated containment pressure for both the original and enhanced shield building designs is less than the maximum containment capacity limit of 143.7 psia at 24 hours after event initiation. Reference 17 contains the formal calculations and is the technical basis for the analyses depicted in Figures 9-1 and 9-2.

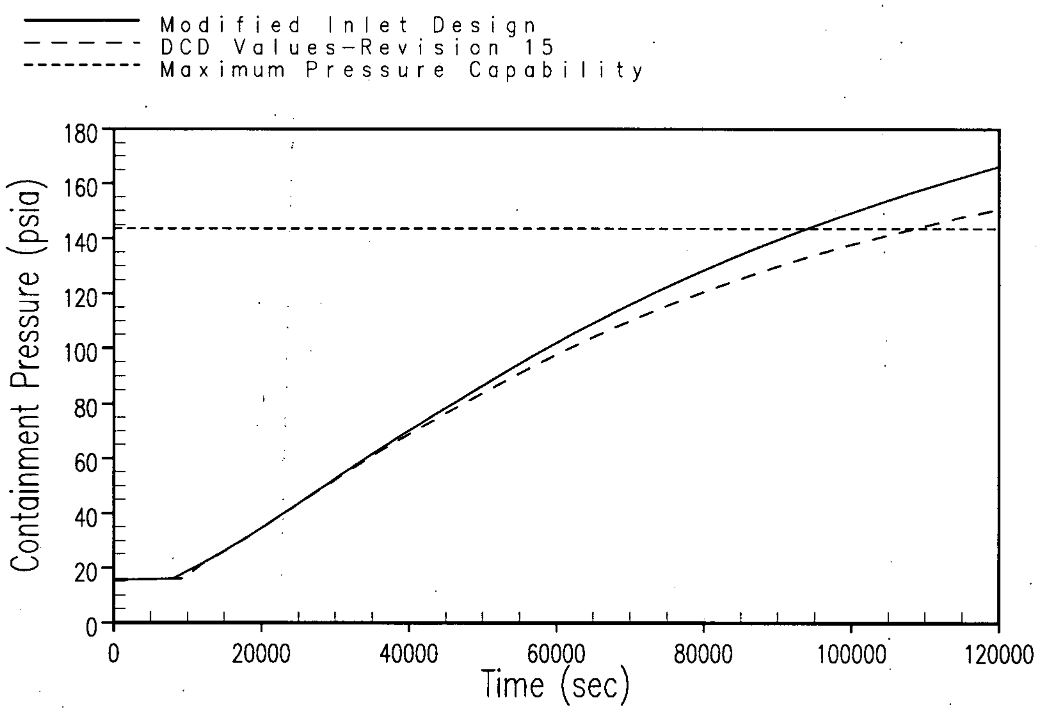


Figure 9-1: Containment Pressure Response Comparison for a BDBA SBO Event with Air Only Cooling

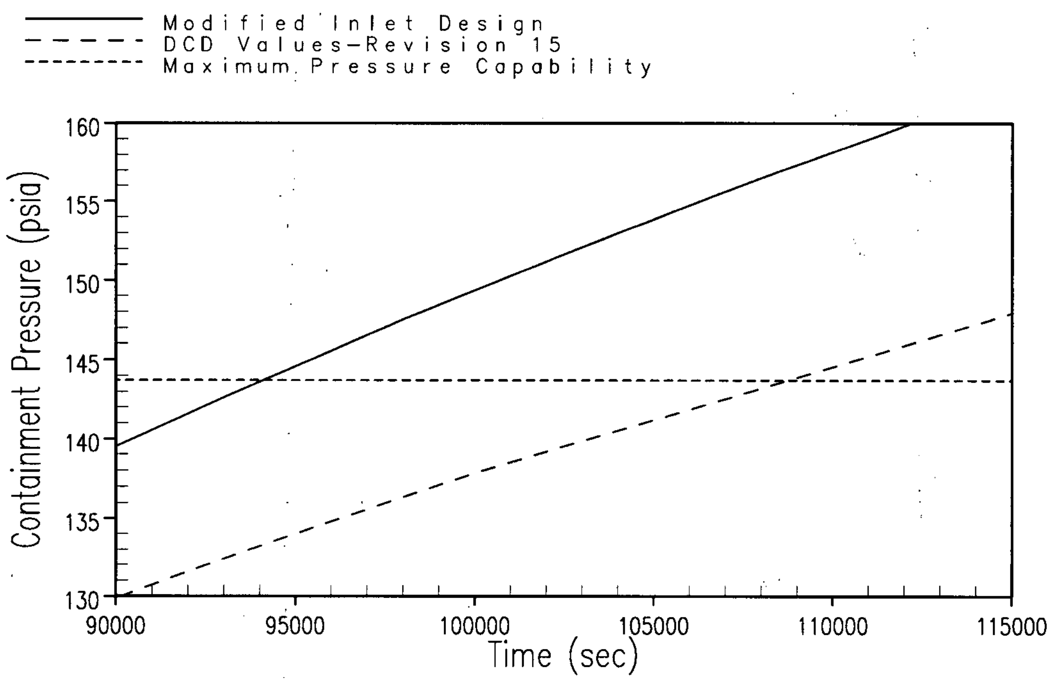


Figure 9-2: Containment Pressure Response Comparison for a BDBA SBO Event with Air Only Cooling Expanded View

10.0 Airflow Path Surveillance Frequency

An air flow path is provided to direct air along the outside of the containment shell to provide containment cooling. The air flow path includes a screened shield building inlet, an air baffle that divides the outer and inner flow annuli, and a chimney to increase buoyancy. The air flow inlet and chimney regions are both designed to protect against ice or snow buildup and to prevent foreign objects from entering the air flow path.

Technical Specification Surveillance Requirement 3.6.6.5 states: Verify the air flow path from the shield building annulus inlet to the exit is unobstructed and, that all air baffle sections are in place. The required frequency is 24 months.

In the enhanced Shield Building design, the air inlets are still located at the top of the cylindrical portion of the shield building. A steel structure has been added around the top of the shield building cylindrical section. This steel structure contains 29 air inlets that are 9.5 ft high by 12 ft long. These openings are fitted with fixed louvers and screens to prevent the buildup of ice and to restrict birds and insects from entering the shield building. No changes have been made to the screens and louvers so there is no increase in susceptibility to birds or insects entering into the area where the air inlets are located. Therefore, there is no change to the required surveillance frequency.

11.0 Summary

Extensive testing was performed in support of the AP1000 passive containment cooling system. These tests ranged from separate effects tests to determine heat and mass transfer correlations and water distribution, to integral tests that simulate the containment response to a simulated accident. All of these tests, with the exception of the Air Flow Path Characterization Test were determined to be fully applicable to the enhanced shield building design.

The enhanced shield building design results in an increase in the resistance to air flow through the passive containment cooling system. A conservative assessment of the resistance was performed and was used to modify the AP1000 WGOTHIC evaluation model to determine the effect on the containment pressure response for design basis and beyond design basis events.

For the design basis events, where the PCS water is assumed to be available, the evaporative heat transfer from the outside of the containment shell compensates for the small reduction in the annulus air flow rate by slightly increasing the PCS outlet temperature and corresponding water vapor fraction. This results in essentially no change in the total heat removal from the shell and no discernable change in the peak containment pressure. The calculated containment pressure exceeds the design limit for the loss of shutdown decay heat removal event without PCS water. Therefore, the upper limit for the core decay heat with air-only containment cooling must be reduced from 9 MWt to 6 MWt.

For the beyond design basis events, the PCS water is assumed not to be available. The reduced annulus air flow rate due to the enhanced shield building design results in a higher calculated containment atmosphere pressure and temperature than the original design. The difference in the calculated containment pressure becomes more pronounced over time. However, at 24 hours after event initiation, the calculated containment pressure still remains below the maximum pressure capacity of the containment.

References

1. WCAP-15613, "AP1000 PIRT and Scaling Assessment," February 2001.
2. WCAP-14812, Rev. 2, "Accident Specification and Phenomena Evaluation for AP600 Passive Containment Cooling System," April 1998.
3. WCAP-12665, Rev. 1, "Tests of Heat Transfer and Water Film Evaporation on a Heated Plate Simulating Cooling of the AP600 Reactor Containment," April 1992.
4. APP-SSAR-GSC-717, Rev. 0, "AP1000 Shield Building DCP Evaluation – Scaling Support," July 2010.
5. WCAP-13294, "Phase I Wind Tunnel Testing for the Westinghouse AP600 Reactor," April 1992.
6. WCAP-13323, "Phase II Wind Tunnel Testing for the Westinghouse AP600 Reactor," August 1992.
7. WCAP-14068, "Phase IVa Wind Tunnel Testing for the Westinghouse AP600 Reactor," May 1994.
8. WCAP-14169, "Phase IVa Wind Tunnel Testing for the Westinghouse AP600 Reactor, Supplemental Report," September 1994.
9. WCAP-14091, "Phase IVb Wind Tunnel Testing for the Westinghouse AP600 Reactor," July 1994.
10. WCAP-13960, "PCS Water Distribution Phase 3 Test Data Report," December 1993.
11. WCAP-14134, "AP600 Passive Containment Cooling System Integral Small-Scale Tests Final Report," August 1994.
12. PCS-T2R-032 Rev. 3, "Final Data Report for PCS Large-Scale Phase 2 and Phase 3 Tests, Rev. 1" October 1998.
13. APP-1208-T2R-101, "AP1000 Shield Building—Scale Model Testing of AP1000 Robust Containment Air Flow Testing (RAFT) at Oregon State University—Test Analysis Report," June 2010.
14. NTD-NRC-95-4563, "GOTHIC Version 4.0 Documentation," 1995.
15. WCAP-15846, WGOTHIC Application to AP600 and AP1000, 2004.
16. APP-SSAR-GSC-746, Rev. 0, "Containment Response Analysis for the AP1000 Shield Building Design Change," January 2010.
17. APP-SSAR-GSC-749, Rev. 0, "AP1000 Dry Heat Removal Capability," July 2010.

Appendix A Required Mark-ups for DCD Rev. 18

The changes reflected in the enhanced shield building design do not significantly impact the design basis and beyond design basis safety analysis, but they do have a substantial impact on the AP1000 design, as documented in DCD Rev. 17. These design impacts are mostly concentrated in the PCS, Spent Fuel Pool (SFS) system, and the Technical Specifications. This appendix will specify the required DCD markups and associated change descriptions for the above mentioned DCD sections.

DCD Sections Impacted:

Tier 2

i. Table 6.2.1.1-3*
ii. 6.2.2.4.2
iii. Table 6.2.2-1
iv. 9.1.2.2
v. 9.1.3
vi. 9.1.4
vii. Table 9.1-4
viii. 16.2.5
ix. Table 16.3.3.2-1
x. Table 16.3.3.5-1
xi. 16.3.6.7
xii. 16.3.7.9
xiii. Table 16 B.3.0-1
xiv. 16B 3.3.2
xv. 16B 3.6.7
xvi. 16B 3.7.9

**In addition to the DCD mark-ups which were changed by the enhanced shield building air inlet design, there was also a change to the External Pressure results in Table 6.2.1.1-3. Although there were no actual changes within the results, the original value in Table 6.2.1.1-3 was the containment differential pressure at 30 minutes. The number was changed to represent the value at one hour to be consistent with the text in Section 6.2.1.1.4 of the DCD.*

Summary Description of DCD Changes

Proposed Changes:

A. Update DCD Tier 2 Chapters 9 and 16 to lower the required reactor decay heat limit for air-only containment cooling from 9 MWt to 6 MWt.
B. Update DCD Tier 2 Chapters 9 and 16 to add the Cask Loading Pit (CLP) as a safety-related source of makeup to the SFP and raise the required spent fuel pool decay heat limit for which the PCCWST must be available, from 5.6 MWt to 7.2 MWt.
C. Update DCD Tier 2 Chapters 6 and 9 to include the post-72 hour water flow rates that the PCS must provide simultaneously for both containment cooling and Spent Fuel Pool makeup following a loss of normal shutdown decay heat removal event during a refueling outage.
D. Update DCD Tier 2 Chapter 16 to close and deactiviate one of the MOV isolation valves in each flow path from the PCCWST to the distribution bucket when the reactor decay heat is ≤ 6 MWt and the PCCWST is required for SFP makeup.

The passive containment cooling water storage tank (PCCWST) provides a safety-related source of containment cooling water in the event of an accident. The AP1000 Technical Specifications require the PCCWST to be available for containment cooling when reactor decay heat is > 9 MWt. Air-only cooling was thought to be sufficient to remove 9 MWt of decay heat. It has been identified that PCS air-only cooling is not sufficient to ensure that containment pressure will be maintained below design pressure at 9 MWt decay heat. The Technical Specifications must be updated to replace 9 MWt with 6 MWt to ensure that air-only cooling of containment is sufficient to ensure containment design pressure is not exceeded.

The Technical Specifications also require that the PCCWST be available to provide makeup water to the SFP when the pool decay heat is > 5.6 MWt. The PCCWST cannot be available for both containment cooling and SFP makeup simultaneously. Once enough fuel has been transferred to the SFP to raise the decay heat in the SFP to 5.6 MWt, the PCCWST must be available as a safety-related source for SFP makeup. However, during normal refueling operations, the reactor decay heat would still be greater than 6 MWt, thus the PCCWST would not be available for SFP makeup since it is still required as safety-related source for containment cooling. If no other change were made, this would adversely impact the outage schedule.

To mitigate the negative impact on the refueling outage schedule, a new safety-related source of SFP makeup will be credited to raise the SFP decay heat limit for which the PCCWST must be available. The Cask Loading Pit contains sufficient water to allow the spent fuel pool decay heat limit to be raised from 5.6 MWt to 7.2 MWt.

In reviewing the updates to the PCS and spent fuel pool decay heat limits, it was recognized that if a DBA were to occur during a refueling outage, the post-72 hour to 7 day onsite support licensing requirements would not be met. In specific refueling scenarios, where the full core is split between the reactor and the SFP during defueling, the PCS would not be capable of providing the necessary makeup to ensure the fuel remains covered in the SFP per the flowrate specified in DCD Tier 2 Chapters 6 and 9. The respective chapters of the DCD will be updated to accommodate the decay heat loads in the SFP.

Per the current Technical Specifications, even after the PCCWST is required to be available for the SFP makeup, the PCCWST isolation valves can still be actuated automatically via High-2 signals from the containment pressure sensors. This would require an operator action to close the valves within 24 hours to ensure the PCCWST contents are sufficient for SFP makeup. DCD Tier 2 Chapter 16 will be updated to close and deactivate one of the isolation valves in each flow path when the PCCWST is not required for containment cooling to prevent the need for operator action.

A. Required DCD Tier 2 Chapter 9 and Technical Specification Changes Related to PCS Operation:

Update DCD Tier 2 Chapters 9 and 16 to lower the required reactor decay heat limit for air-only containment cooling from 9 MWt to 6 MWt.

During a loss of onsite and offsite power or a safe shutdown earthquake, the normal residual heat removal system (RNS) active cooling capabilities are lost. The passive core cooling system (PXS) will transfer heat to the IRWST and could eventually cause it to boil. The steam released via boiling in the IRWST would raise containment pressure and temperature. The passive containment cooling system (PCS) must ensure that heat is removed at a sufficient rate such that containment design pressure (59 psig) is not exceeded during the accident.

The PCCWST is required to be available for containment cooling when the reactor decay heat is > 9 MWt to ensure sufficient heat is removed per the Technical Specification, DCD Chapter 16 Section 3.6.7. While the plant is in Modes 5 or 6, air-only cooling of the containment using the PCS airflow path was considered sufficient to remove 9 MWt of decay heat such that during a loss or RNS event, containment pressure would not exceed design pressure. It has been identified [CAPS number 10-173-M034] that PCS air-only cooling is not sufficient to maintain containment pressure below the design pressure following a loss of RNS event when the reactor decay heat is at 9 MWt. Reference Figure 2019-01 "Containment Pressure during a PCS Air Only Cooling DBA with Initial Reactor Decay Heat Load."

The PCS Technical Specifications must be updated to reduce the upper limit for reactor decay heat from 9 MWt to 6 MWt to ensure containment design pressure is not exceeded when the PCCWST is not available and PCS air-only cooling is relied upon. The new reactor decay heat maximum value of 6 MWt is calculated per APP-SSAR-GSC-749, "AP1000 Dry PCS Heat Removal Capability".

The PCS SSD will be updated with the new air-only containment cooling limit of 6 MWt. The PCCWST and associated flow paths will function the same as before. The only operations-related change is the point at which the PCCWST must be available as a makeup source of water to the SFP vice containment cooling. This change must be appropriately captured in the AP1000 plant cooldown and refueling operating procedures.

B. Required DCD Tier 2 Chapter 9 and Technical Specification Changes Related to SFP Operation:

Update DCD Tier 2, Chapters 9 and 16 to add the Cask Loading Pit (CLP) as a safety-related source of makeup to the SFP and raise the required Spent Fuel Pool decay heat limit for which the PCCWST must be available from 5.6 MWt to 7.2 MWt.

During a loss of onsite and offsite power or a safe shutdown earthquake, the spent fuel pool cooling system (SFS) active cooling capabilities are lost. Currently utilizing the contents of the SFP and Cask Washdown Pit (CWP), the SFP can passively ensure fuel cooling by boiling the available water for 72 hours. Currently, if the decay heat to the SFP exceeds 5.6 MWt, there is not enough water available to ensure the fuel will remain covered for 72 hours. The PCCWST must be available as a safety-related source of makeup once the SFP decay heat is > 5.6 MWt per the Technical Specifications, DCD Chapter 16 Section 3.7.9.

To ensure there are no impacts to the refueling outage schedule, this DCP proposes adding the Cask Loading Pit (CLP) as a safety-related source of makeup to the SFP. The CLP will allow fuel to continue to be transferred to the SFP until the total decay heat load in the SFP is 7.2 MWt before the PCCWST must be available for makeup.

To align the CLP to the SFP, the water level in both pits must be equalized. The gate between the two pits will then be opened connecting the two pits.

Additonal changes to the boiloff times in DCD Table 9.1-4 are proposed. These additional changes were not due to adding the CLP as a safety related makeup source to the SFP. When calculating the time to saturation in APP-SFS-M3C-012, an hour's worth of heat input was assumed to have occurred at time t=0. However, that hour's worth of heat should have been assumed to be added by time t=1 hour. This correction effectively adds 1 hour to the calculated time to reach saturation temperature.

The Fuel Storage Pool Makeup Water Sources Technical Specifications must be updated to ensure the CLP is available as a source of makeup once the SFP decay heat is > 5.6 MWt and the PCCWST is available once the SFP decay heat is > 7.2 MWt. These values are calculated in APP-SFS-M3C-012, "AP1000 Spent Fuel Pool Heatup, Boiloff, and Emergency Makeup on Loss of Cooling."

C. Required DCD Tier 2 Chapters 6 and 9 Changes Related to PCS Post-72 Hour Onsite Support:

> Update DCD Tier 2 Chapters 6 and 9 to include flowrates that the PCS must provide simultaneously for both containment cooling and Spent Fuel Pool makeup post-72 hours after a DBA during a refueling outage.

In reviewing the updates to the PCS and spent fuel pool decay heat limits, it was recognized that if a DBA were to occur during a refueling outage, the post-72 hour to 7 day onsite support licensing requirements would not be met. In specific refueling scenarios, where the full core is split between the reactor and the SFP during defueling, the PCS would not be capable of providing the necessary makeup to ensure the fuel remains covered in the SFP per the flowrate specified in DCD Tier 2 Chapters 6 and 9. These scenarios can occur when decay heat is > 6.0 MWt in the reactor and < 7.2 MWt in the SFP where the PCCWST is required for containment cooling and cannot be used for SFP makeup.

The PCS must be capable of providing containment cooling and spent fuel pool makeup simultaneously from post-72 hours to 7 days after the initiation of the DBA. The PCS is limited in its capabilities to supplying 135 gpm total. The flowrates are currently specified in the DCD as a minimum of 100 gpm to containment and a minimum of 35 gpm to the spent fuel pool from the passive containment cooling ancillary water storage tank (PCCAWST) using one PCS recirculation pump. The plant condition associated with 35 gpm is a loss of power combined with a seismic event when the plant is operating at full power, shortly after startup from a refueling outage. When the plant is not at power and defueling has commenced, more fuel, and thus decay heat, is located in the SFP then when at power. The requirement of 100 gpm is based on the containment cooling requirements post-72 hours after a limiting DBA occurring at full power. The decay heat in the reactor in a plausible DBA during refueling will always require less than 100 gpm in the post-72 hours interim because the reactor will have been shutdown for an extra 100 hours due to the time required to cooldown and depressurize the RCS.

In a DBA during refueling, the plant condition includes a loss of power combined with a seismic event. This refueling scenario considers the time between completion of plant cooldown (100 hours after shutdown) and just prior to plant startup once the refueling is complete. With the additional decay heat in the spent fuel pool because of the recent offload, the makeup to the SFP will increase from 35 gpm to 50 gpm (APP-SFS-M3C-012). To obtain the additional makeup flow to the SFP, the required flowrate for containment cooling will be reduced from 100 gpm to 80 gpm (APP-SSAR-GSC-750). The respective chapters of the DCD will be updated to reflect this new set of flowrates and the refueling DBA scenario as it applies to post-72 hour to 7 day onsite support.

It should be noted that the PCS is sufficiently designed to handle these new flowrates, for example, pipe size, instrumentation capability and location, etc.

D. Required DCD Tier 2 Chapters 16 Changes Related to PCCWST Flowpath Isolation:

Update DCD Tier 2 Chapter 16 to close and deactivate one of the MOV isolation valves in each flow path from the PCCWST to the distribution bucket when the reactor decay heat is ≤ 6 MWt and the PCCWST is required for SFP makeup.

As previously discussed, the PCCWST is required for containment cooling when the reactor decay heat is > 6 MWt. During refueling, once enough fuel has been offloaded from the reactor such that total decay heat is ≤ 6 MWt, air-only containment cooling is sufficient and the PCCWST may be available for the SFP as a safety-related source of makeup. Per the current Technical Specifications, even after the PCCWST is required to be available for the SFP makeup, the PCCWST isolation valves (V001A/B/C) can still be actuated automatically via High-2 signals from the containment pressure sensors during a loss of onsite and offsite power. If the PCCWST isolation valves are opened and the water is drained unnecessarily onto containment instead of being sent to the SFP, the operators have 24 hours to take action to close the valves until SR 3.7.9.1 is violated (the PCCWST volume is drained to < 400,000 gallons). To ensure this operator action is not required, SR 3.7.9.1 has been modified to ensure that one MOV isolation valve (gate valve) is closed and secured prior to the PCCWST becoming OPERABLE for SFP makeup prior to ensuring the PCCWST contains ≥ 400,000 gallons. The PCCWST air-operated isolation valves (V001A/B) cannot be used because they are fail-open. During a loss of onsite and offsite power the valves will lose compressed air and eventually open.

Table 6.2.1.1-1 **SUMMARY OF CALCULATED PRESSURES AND TEMPERATURES**			
Break	**Peak Pressure (psig)**	**Available[1] Margin (psi)**	**Peak Temperature (°F)**
Double-ended hot leg guillotine	50.0	9.0	~~416.5~~ 415.3
Double-ended cold leg guillotine	57.8	1.2	~~284.9~~ 295.1
Full main steamline DER, 30% power, MSIV failure	~~57.3~~ 57.0	~~1.7~~ 2.0	~~373.9~~ 374.1
Full main steamline DER, 101% power, MSIV failure	~~53.7~~ 53.5	~~5.3~~ 5.5	~~375.3~~ 375.5

Note:
1. Design Pressure is 59 psig

Figure A-1: Proposed Changes To DCD Table 6.2.1.1-1

Table 6.2.1.1-3 **RESULTS OF POSTULATED ACCIDENTS**					
Criterion	**Acceptance Criterion Value**	**Lumped DEHLG LOCA Value**	**Lumped DECLG LOCA Value**	**30% Power MSLB Value**	**External Pressurization Value**
GDC 16 & GDC 50 Design Pressure	<59.0 psig	50.0	57.8	~~57.3~~ 57.0	
GDC 38 Rapidly Reduce Containment Pressure	< 29.5 psig		22 at 24 hrs		
GDC 38 & 50 External Pressure	< 2.9 psid				~~2.4~~ 2.86
GDC 38 & GDC 50 Containment Heat Removal Single Failure	Most Severe	Two of Three Trains of PCS Water Supply	Two of Three Trains of PCS Water Supply	Two of Three Trains of PCS Supply	

Figure A-2: Proposed Changes To DCD Table 6.2.1.1-3

6.2.2.3 Safety Evaluation

The safety-related portions of the passive containment cooling system are located within the shield building structure. This building (including the safety-related portions of the passive containment cooling system) is designed to withstand the effects of natural phenomena such as earthquakes, winds, tornadoes, or floods. Components of the passive containment cooling system are designed to withstand the effects of ambient temperature extremes.

The portions of the passive containment cooling system which provide for long term (post 72-hour) water supply for containment wetting are located in Seismic Category I or Seismic Category II structures excluding the passive containment ancillary water storage tank and associated valves located outside of the auxiliary building. The water storage tank and the anchorage for the associated valves are Seismic Category II. The features of these structures which protect this function are analyzed and designed for Category 5 hurricanes including the effects of sustained winds, maximum gusts, and associated wind-borne missiles.

Operation of the containment cooling system is initiated automatically following the receipt of a Hi-2 containment pressure signal. The use of this signal provides for system actuation during transients, resulting in mass and energy releases to containment, while avoiding unnecessary actuations. System actuation requires the opening of any of the three normally closed isolation valves, with no other actions required to initiate the post-accident heat removal function since the cooling air flow path is always open. Operation of the passive containment cooling system may also be initiated from the main control room and from the remote shutdown workstation. A description of the actuation system is contained in Section 7.3.

The active components of the passive containment cooling system, the isolation valves, are located in three redundant pipe lines. Failure of a component in one train does not affect the operability of the other mechanical train or the overall system performance. The fail-open, air-operated valves require no electrical power to move to their safe (open) position. The normally open motor-operated valves are powered from separate redundant Class 1E dc power sources. Table 6.2.2-3 presents a failure modes and effects analysis of the passive containment cooling system.

Capability is provided to periodically test actuation of the passive containment cooling system. Active components can be tested periodically during plant operation to verify operability. The system can be inspected during unit shutdown. Additional information is contained in subsections 3.9.6 and 6.2.2.4, as well as in the Technical Specifications.

The passive containment cooling system components located inside containment, the containment pressure sensors, are tested and qualified to perform in a simulated design basis accident environment. These components are protected from effects of postulated jet impingement and pipe whip in case of a high-energy line break.

The containment pressure analyses are based on an ambient air temperature of 115°F dry bulb and 86.1°F coincident wet bulb. The passive containment cooling water storage tank water temperature basis is 120°F. Results of the analyses are provided in subsection 6.2.1.

The shield building air inlets were changed as part of the enhanced shield building design. The impact of these changes on the containment pressure analyses is small and the conclusions remain valid. The analyses provided in subsection 6.2.1 include the air inlet changes (Reference 33).

Figure A-3: Proposed changes to DCD Section 6.2.2.3

containment vessel and air baffle retains provisions for the inspection of the vessel during plant shutdowns.

6.2.2.4.2 Preoperational Testing

Preoperational testing of the passive containment cooling system is verified to provide adequate cooling of the containment. The flow rates are confirmed at the minimum initial tank level, an intermediate step with all but one standpipe delivering flow and at a final step with all but two standpipes delivering to the containment shell. The flow rates are measured utilizing the differential pressure across the orifices within each standpipe and will be consistent with the flow rates specified in Table 6.2.2-1.

The containment coverage will be measured at the base of the upper annulus in addition to the coverage at the spring line for the full flow case using the PCS water storage tank delivering to the containment shell and a lower flow case with both PCS recirculation pumps delivering to the containment shell. For the low flow case, a throttle valve is used to obtain a low flow rate less than the full capacity of the PCS recirculation pumps. This flow rate is then re-established for subsequent tests using the throttle valve. These benchmark values will be used to develop acceptance criteria for the Technical Specifications. The full flow condition is selected since it is the most important flow rate from the standpoint of peak containment pressure and the lower flow rate is selected to verify wetting characteristics at less than full flow conditions.

The standpipe elevations are verified to be at the values specified in Table 6.2.2-2.

The inventory within the tank is verified to provide 72 hours of operation from the minimum initial operating water level with a minimum flow rate over the duration in excess of 100.7 gpm. The flow rates are measured utilizing the differential pressure across the orifices within each standpipe.

The containment vessel exterior surface is verified to be coated with an inorganic zinc coating.

The passive containment cooling air flow path will be verified at the following locations:

- Air inlets
- Base of the outer annulus
- Base of the inner annulus
- Discharge structure

With either a temporary water supply or the passive containment cooling ancillary water storage tank connected to the suction of the recirculation pumps and with either of the two pumps operating, flow must be provided simultaneously ~~the flow rate~~ to the passive containment cooling water storage tank ~~will be in excess of~~ at greater than or equal to 100 gpm~~.~~ and to the spent fuel pool at greater than or equal to 35 gpm. This must also be accomplished at simultaneous flow rates greater than or equal to 80 gpm to the passive containment cooling water storage tank and greater than or equal to 50 gpm to the spent fuel pool. Temporary instrumentation or changes in the passive containment cooling water storage tank level will be utilized to verify the flow rates. The capacity of the passive containment cooling ancillary water storage tank is verified to be

Figure A-4a: Proposed changes to DCD Section 6.2.2.4.2

adequate to supply 135 gpm for a duration of 4 days (~~100 gpm for~~ for passive containment cooling and ~~35 gpm for~~ spent fuel pool ~~cooling~~makeup).

The passive containment cooling water storage tank provides makeup water to the spent fuel pool. When aligned to the spent fuel pool the flow rate is verified to exceed 118 gpm. Installed instrumentation will be utilized to verify the flow rate. The volume of the passive containment cooling water storage tank is verified to exceed the minimum usable volume defined in Table 6.2.2-2. ~~The passive containment cooling ancillary water storage tank recirculation pumps can provide makeup to the spent fuel pool. The flow rate is verified to exceed 35 gpm to the spent fuel pool.~~

Additional details for preoperational testing of the passive containment cooling system are provided in Chapter 14.

6.2.2.4.3 Operational Testing

Operational testing is performed to:

- Demonstrate that the sequencing of valves occurs on the initiation of Hi-2 containment pressure and demonstrate the proper operation of remotely operated valves.
- Verify valve operation during plant operation. The normally open motor-operated valves, in series with each normally closed air-operated isolation valve, are temporarily closed. This closing permits isolation valve stroke testing without actuation of the passive containment cooling system.
- Verify water flow delivery and containment water coverage, consistent with the accident analysis.
- Verify visually that the path for containment cooling air flow is not obstructed by debris or foreign objects.
- Test frequency is consistent with the inservice testing program (subsection 3.9.6).

6.2.2.5 Instrumentation Requirements

The status of the passive containment cooling system is displayed in the main control room. The operator is alerted to problems with the operation of the equipment within this system during both normal and post-accident conditions.

Normal operation of the passive containment cooling system is demonstrated by monitoring the recirculation pump discharge pressure, flow rate, water storage tank level and temperature, and valve room temperature. Post-accident operation of the passive containment cooling system is demonstrated by monitoring the passive containment cooling water storage tank level, passive containment cooling system cooling water flow rate, containment pressure, and external cooling air discharge temperature.

The information on the activation signal-generating equipment is found in Chapter 7.

Figure A-4b: Proposed changes to DCD Section 6.2.2.4.2 (Cont'd)

25. Not used.

26. WCAP-15965-P (Proprietary) and WCAP-15965-NP (Non-Proprietary), "AP1000 Subcompartment Models," November 2002.

27. Not used.

28. Not used.

29. EPRI Report TR-107517, Volumes 1, 2, and 3, "Generic Model Tests of Passive Autocatalytic Recombiners (PARs) for Combustible Gas Control in Nuclear Power Plants," June 1997.

30. Nuclear Energy Institute Report, NEI 94-01, "Industry Guidelines for Implementing Performance Based Option of 10 CFR 50, Appendix J," Revision 0.

31. Carlin, E. L. and U. Bachrach, "LOFTRAN and LOFTTR2 AP600 Code Applicability Document," WCAP-14234, Revision 1 (Proprietary) and WCAP-14235, Revision 1 (Non-Proprietary), August 1997.

32. WCAP-15644-P (Proprietary) and WCAP-15644-NP (Non-Proprietary), "AP1000 Code Applicability Report," Revision 2, March 2004.

33. APP-GW-GLR-096, Evaluation of the Effect of AP1000 Enhanced Shield Building Design on the Containment Response and Safety Analysis

Figure A-5: Proposed changes to DCD Section 6.2.7

Table 6.2.2-1

PASSIVE CONTAINMENT COOLING SYSTEM PERFORMANCE PARAMETERS

PCCWST useable capacity for PCS (gal) - Minimum	756,700
PCCWST useable capacity for FPS[2] (gal) - Minimum	18,000
Flow duration from PCCWST (days) - Minimum	3
PCCWST minimum temperature (°F)	40
PCCWST maximum temperature (°F)	120
Upper annulus drain rate (per drain) - Minimum	525 gpm
PCCAWST[4] long-term makeup rate to containment - Minimum[7]	100 gpm
PCCAWST long-term makeup to spent fuel pool - Minimum[7]	35 gpm
PCCAWST long-term makeup duration - Minimum	4 days
PCCWST long-term makeup to spent fuel pool – Minimum	118 gpm

PCCWST Water Elevation (Note 3) (feet)	Nominal Design Flow (gpm)	Minimum Design Flow (gpm)	Safety Analysis Flow (gpm)	Wetted Coverage (Note 3) (% of circumference)
27.5	494.6 (Note 5)	471.1	469.1	90
24.1	247.1	238.4	226.6	90
20.3	190.8	184.0	176.3	72.9
16.8	157.1	151.4	144.2	59.6
4.0 (Note 6)	113.1	109.6		
			100.7 @ 72 hours	41.6

Notes:
1. PCCWST = passive containment cooling water storage tank
2. FPS = fire protection system
3. PCCWST Water Elevation corresponds to the nominal standpipe elevations in feet above the tank floor (Reference Plant Elevation 293'-9". see Figure 3.8.4-2). Wetted coverage is measured as the linear percentage of the containment shell circumference wetted measured at the upper spring line for the safety analysis flow rate conditions.
4. PCCAWST = passive containment cooling ancillary water storage tank
5. The initial nominal design flow is based on the nominal PCCWST water elevation.
6. This elevation is the calculated water level at 72 hours after initiation of PCS flow, based on the minimum design flow rates.
7. These flow rates apply when the plant is not refueling. The minimum makeup flow rates required when the plant is being refueled are 80 gpm to containment and 50 gpm to the spent fuel pool. The minimum makeup flow rates are adjusted because more decay heat is located in the spent fuel pool. See section 9.1.3 for additional details.

Figure A-6: Proposed changes to DCD Table 6.2.2-1

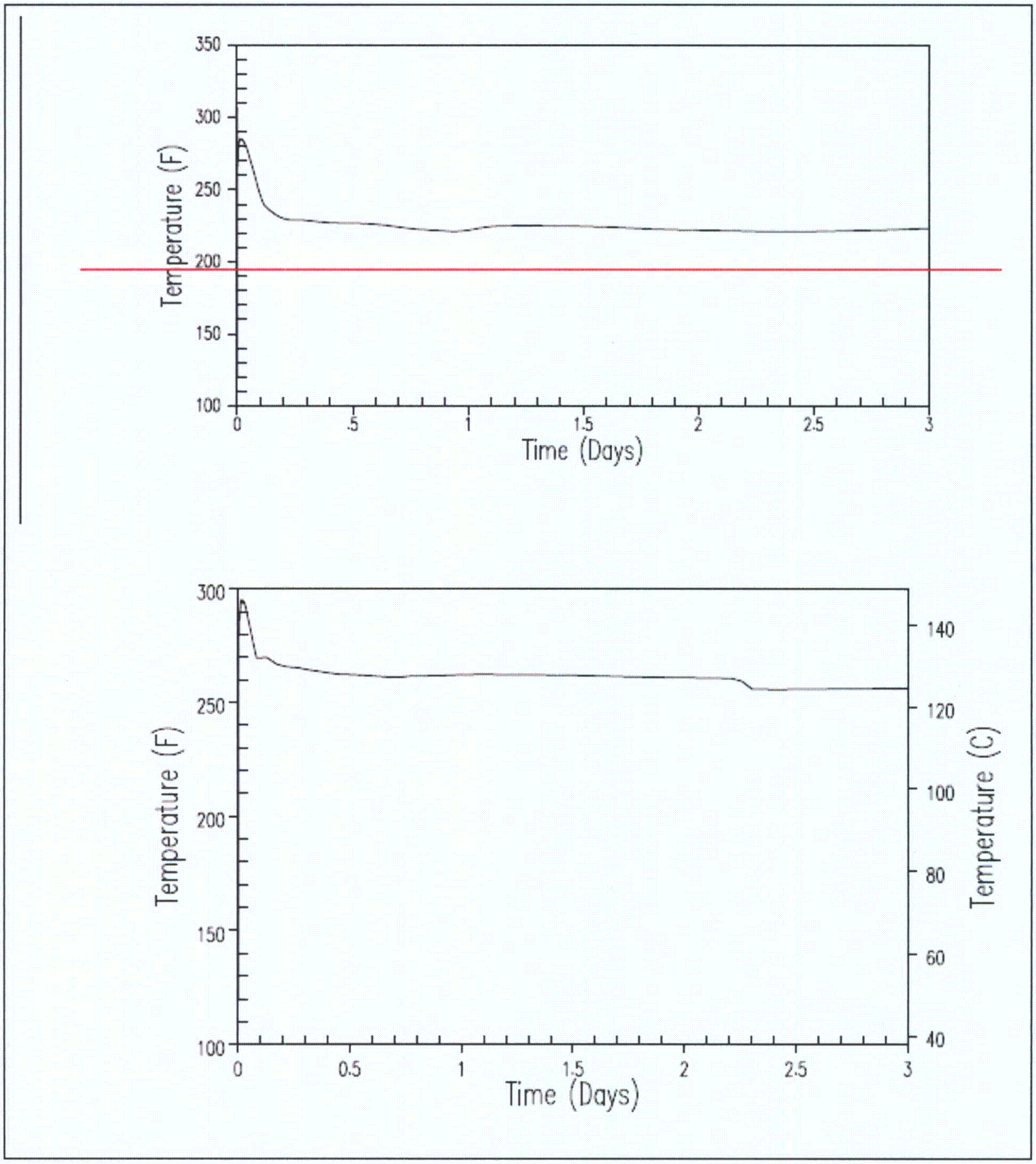


Figure A-7: Proposed Changes To DCD Figure 6.2.1.1-8

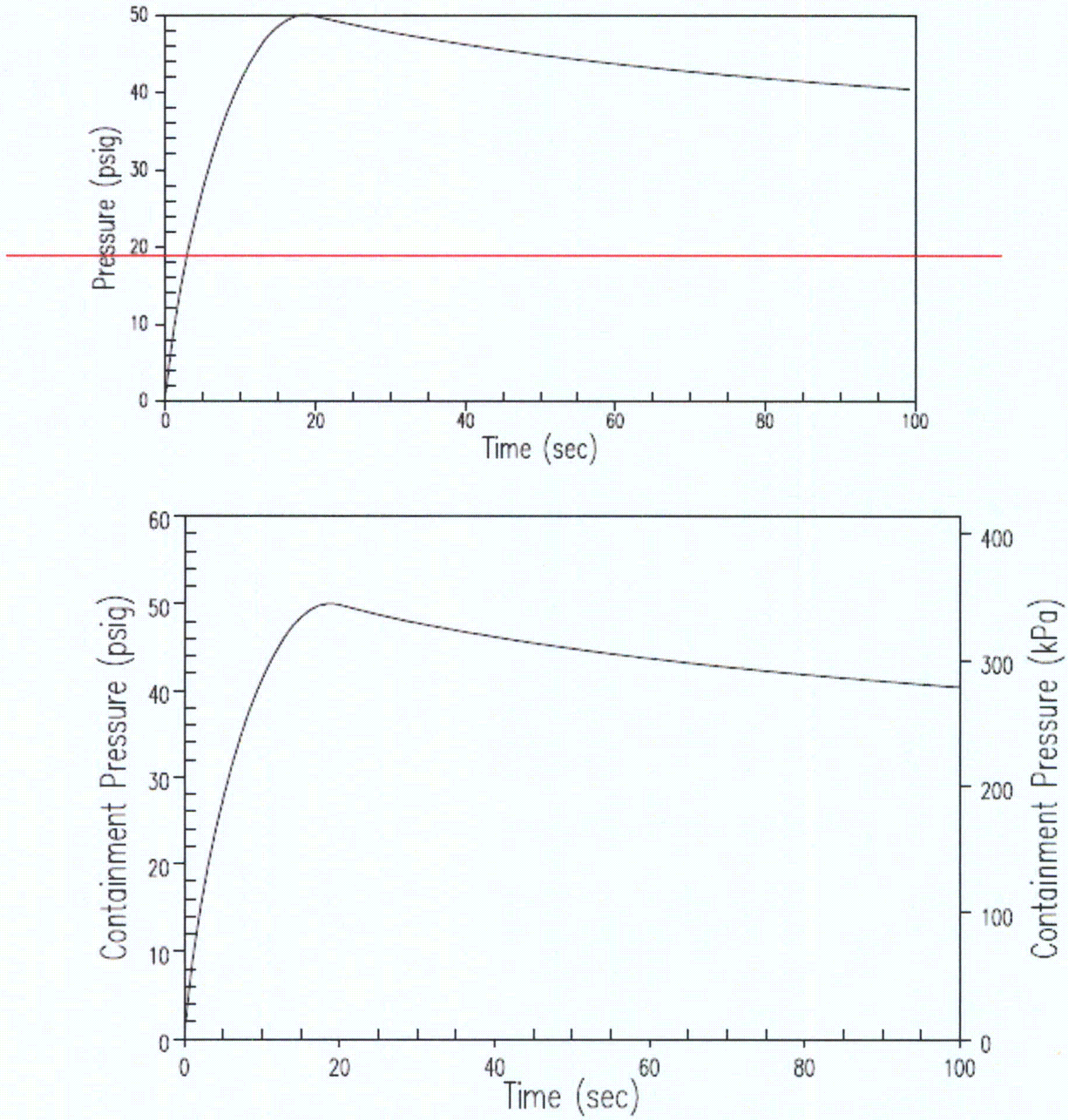
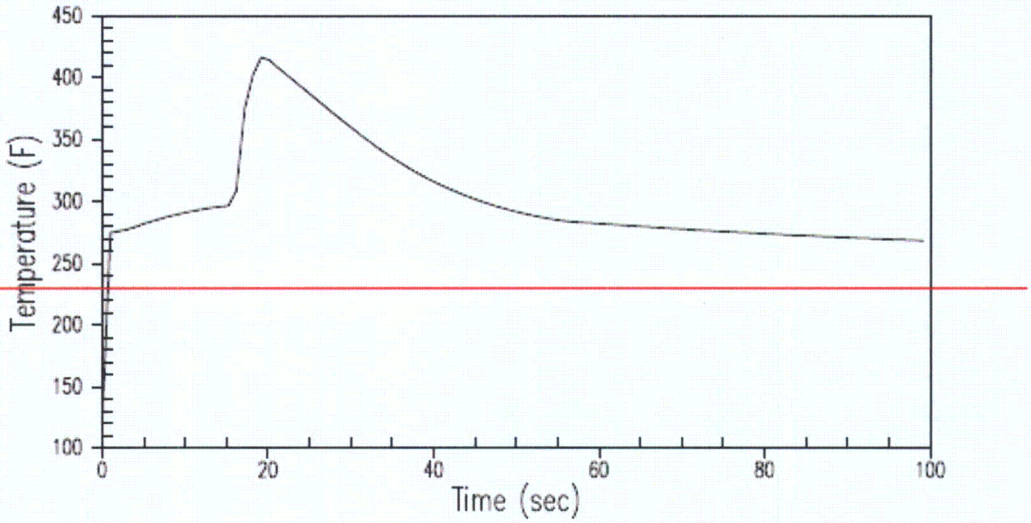


Figure A-8: Proposed Changes To DCD Figure 6.2.1.1-9



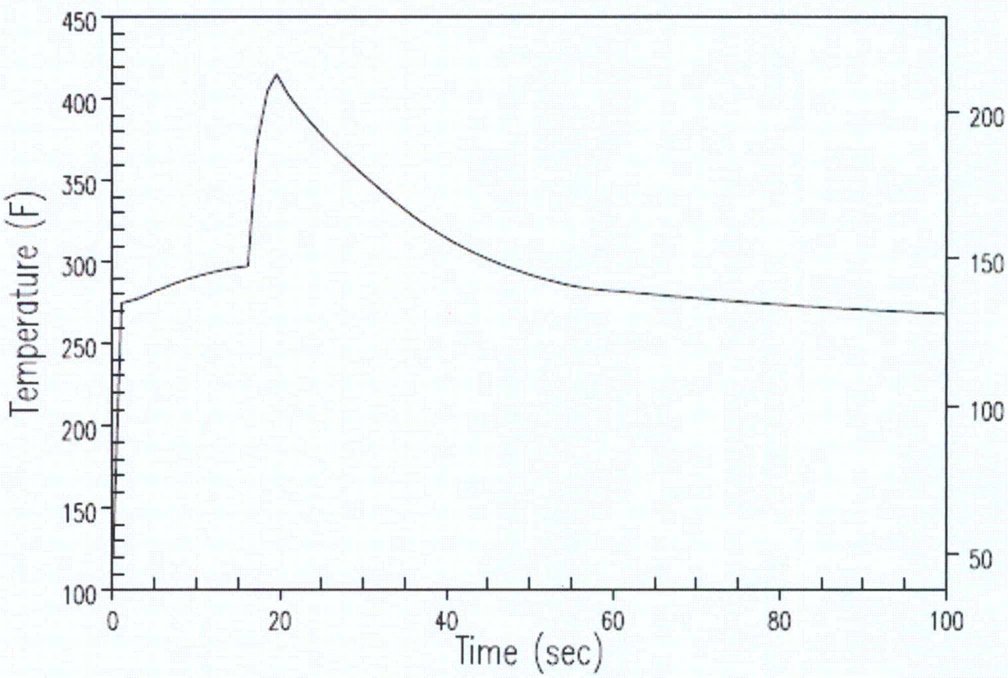
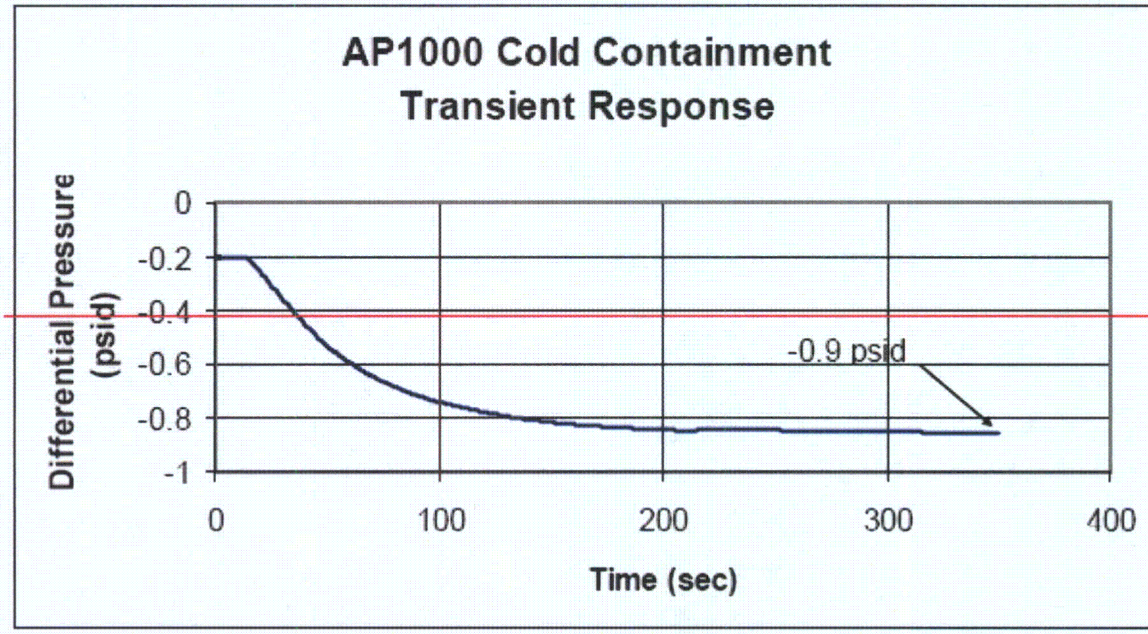


Figure A-9: Proposed Changes To DCD Figure 6.2.1.1-10



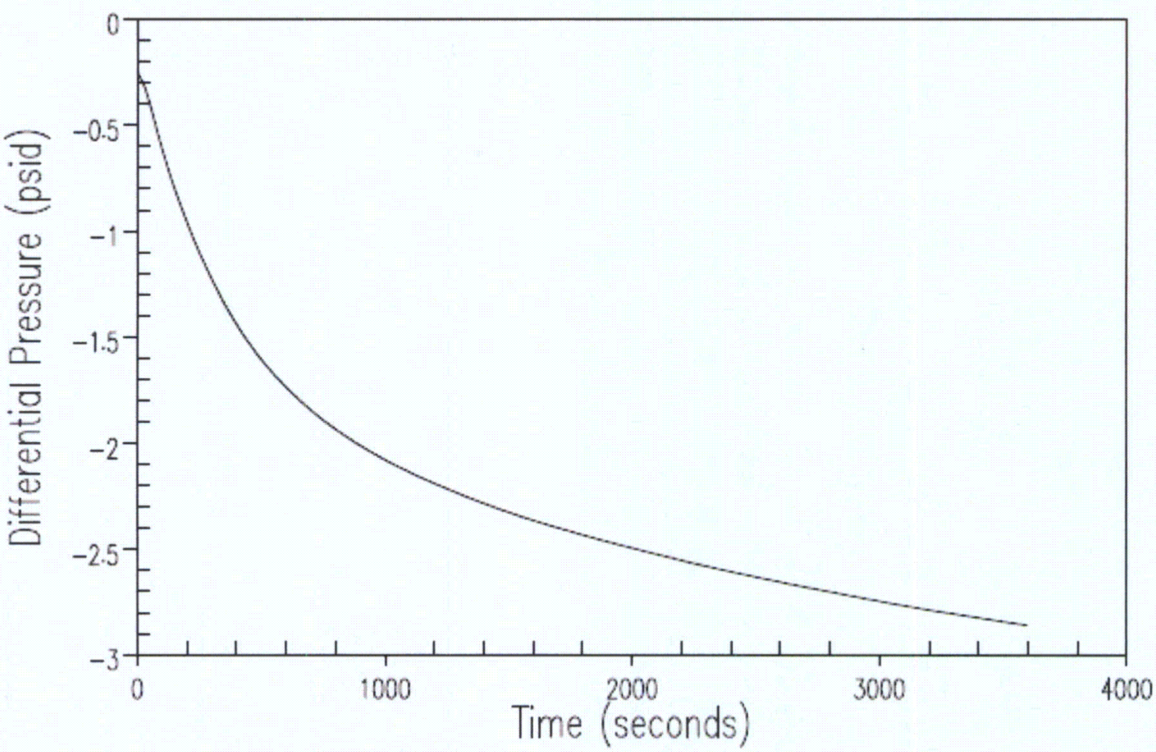


Figure A-10: Proposed Changes To DCD Figure 6.2.1.1-11

metal gate with gasket assembly separates the spent fuel pool and fuel transfer canal. This allows the fuel transfer canal to be drained without reducing the water level in the spent fuel pool. During normal operation, this gate remains open and is only closed to drain the canal. The bottom of the fuel transfer canal has a drain connected to safety-related piping and isolation valves which prevents inadvertent draining after a seismic event. Subsection 9.1.3 further addresses the minimum water level in the spent fuel pool.

Next to the spent fuel pool and accessible by another gated, gasketed opening is a cask loading pit. The cask pit is a lined reinforced concrete structure of the auxiliary building fuel handling area. It is provided for underwater loading of fuel into a shipping cask and cask draining/decontamination prior to cask transshipment from the AP1000 site. The bottom of the cask loading pit has a drain connected to safety-related piping and isolation valve which prevents inadvertent draining after a seismic event. The gate between the spent fuel pool and the cask loading pit is normally closed and opened during refueling and ~~only for~~ cask loading options. The cask loading pit can be used as a source of water for low pressure injection to the reactor coolant system via the normal residual heat removal pumps during an event in which the reactor coolant system pressure and inventory decrease.

The fuel handling machine traverses the spent fuel pool, the fuel transfer canal, the cask loading pit, the new fuel storage pit, and the rail car bay. It is used in the movement of both new and spent fuel assemblies. The fuel handling machine is used to transfer new fuel assemblies from the new fuel storage rack into the spent fuel pool. A new fuel elevator in the spent fuel pool lowers the new fuel to an elevation accessible by the fuel handling machine.

The cask handling crane is used for operations involving the spent fuel shipping cask. The cask handling crane traverses the auxiliary building and a portion of the fuel handling area. The cask handling crane's path is designed such that the cask cannot pass over the spent fuel pool, new fuel pit, or fuel transfer canal. This precludes the movement of loads greater than fuel components over stored fuel in accordance with Regulatory Guide 1.13.

During fuel handling operations, a ventilation system removes gaseous radioactivity from the atmosphere above the spent fuel pool. Refer to subsection 9.4.3 for a discussion of the radiologically controlled area ventilation system, Section 11.5 for process radiation monitoring, subsection 9.1.3 for the spent fuel pool cooling system, and subsection 12.2.2 for airborne activity levels in the fuel handling area.

9.1.2.2.1 Spent Fuel Rack Design

A. Design and Analysis of Spent Fuel Racks

The spent fuel pool rack layout contains both Region 1 rack modules with a center-to-center spacing of nominally 10.9 inches and Region 2 rack modules with a center-to-center spacing of nominally 9.03 inches. Both of these rack module configurations provide adequate separation between adjacent fuel assemblies with neutron absorbing material to maintain a subcritical array.

The material used in the AP1000 fuel storage racks is Metamic®, a metal matrix composite material consisting of a Type 6061 aluminum alloy matrix reinforced with boron carbide

Figure A-11: Proposed Changes to DCD Section 9.1.2.2

At the completion of the refueling, the standby spent fuel pool pump is used to transfer the water in the refueling cavity back to the in-containment refueling water storage tank. Once this is complete, the standby train can be aligned to cool the spent fuel pool or may be placed in standby.

9.1.3.4.3 Abnormal Conditions

The AP1000 spent fuel pool cooling system is not required to operate to mitigate design basis events. In the event the spent fuel pool cooling system is unavailable, spent fuel cooling is provided by the heat capacity of the water in the pool. Connections to the spent fuel pool are made at an elevation to preclude the possibility of inadvertently draining the water in the pool to an unacceptable level.

In the unlikely event of an extended loss of normal spent fuel pool cooling, the water level will drop. Low spent fuel pool level alarms in the control room will indicate to the operator the need to initiate makeup water to the pool. These alarms are provided from safety-related level instrumentation in the spent fuel pool. With the use of makeup water, the pool level is maintained above the spent fuel assemblies for at least 7 days. Initial spent fuel pool water level is controlled by technical specifications. During the first 72 hours any required makeup water is supplied from safety related sources. If makeup water beyond the safety related sources is required between 72 hours and 7 days, water from the passive containment cooling system ancillary water storage tank is provided to the spent fuel pool. The amount of makeup required to provide the 7 day capability depends on the decay heat level of the fuel in the spent fuel pool and is provided as follows:

- When the calculated decay heat level in the spent fuel pool is less than 4.6 MWt, no makeup is needed to achieve spent fuel pool cooling for at least 72 hours.
- When the calculated decay heat level in the spent fuel pool is greater than or equal to 4.6 MWt and less than or equal to 5.6~~5.4~~ MWt, safety related makeup from the cask washdown pit is sufficient to achieve spent fuel pool cooling for at least 72 hours. A minimum level of 13.75 feet in the cask washdown pit is provided for this purpose. Availability of the makeup source is controlled by technical specifications.
- When the calculated decay heat level in the spent fuel pool is greater than 5.6 MWt and less than or equal to 7.2 MWt, safety related makeup from the cask washdown pit and cask loading pit is sufficient to achieve spent fuel pool cooling for at least 72 hours. A minimum level of 13.75 ft in the cask washdown pit and 43.9 ft in the cask loading pit is provided for this purpose. Availability of the makeup sources are controlled by technical specifications.
- When calculated decay heat level in the spent fuel pool is greater than 7.2~~5.4~~ MWt, makeup from the passive containment cooling water storage tank or passive containment cooling ancillary water storage tank, or combination of the two tanks, is sufficient to achieve spent fuel pool cooling for at least 7 days.
- When the decay heat level in the reactor is less than 6~~9~~ MW, the passive containment cooling water storage tank is not needed for containment cooling and this water can be used for makeup to the spent fuel pool. This tank provides safety related makeup for at least 72 hours.

Figure A-12a: Proposed Changes to DCD Section 9.1.3

Between 72 hours and 7 days the tank continues to provide makeup water as required until it is empty. If the passive containment cooling water storage tank empties in less than 7 days, non-safety makeup water can be provided from the passive containment cooling ancillary water storage tank.

- When the decay heat level in the reactor is greater than 69 MW, the water in the passive containment cooling water storage tank is reserved for containment cooling. Safety related spent fuel pool cooling is provided for at least 72 hours from the pool itself and makeup water from the cask washdown pit and cask loading pit. After 72 hours, non-safety related makeup can be provided from the passive containment cooling ancillary water storage tank.

- Minimum volume in the passive containment cooling water storage tank for spent fuel pool makeup is 756,700 gallons. Availability of this makeup source for the first 72 hours is controlled by technical specifications. Minimum volume in the passive containment ancillary water storage tank for spent fuel pool makeup is ~~175,000~~201,600 gallons.

Table 9.1-4 provides the calculated timing and spent fuel pool water levels for several limiting event scenarios which would require makeup to the spent fuel pool.

Alignment of the cask washdown pit is accomplished by positioning manual valves located in the waste monitor tank room B (12365) in the auxiliary building. Alignment of the passive containment cooling water storage tank is accomplished by positioning manual valves located in the mid annulus access room (12345) and in the passive containment cooling valve room in the upper shield building. Because these alignments are made by positioning manual valves, they are not susceptible to active failures.

Alignment of the cask loading pit is accomplished by opening the gate, shown in Figure 9.1-6 located between the cask loading pit and the spent fuel pool. The cask loading pit gate should be opened prior to exceeding 5.6 MWt in the spent fuel pool.

Gravity driven flow from the cask washdown pit to the spent fuel pool is provided as the cask washdown pit water level will follow the spent fuel pool level. Figures 9.1-5 and 9.1-6 show the connection of the cask washdown pit to the spent fuel pool.

Gravity driven flow from the passive containment cooling water storage tank is controlled by a manual throttle valve with local flow indication which is set to achieve the desired flow when the makeup is initiated. Figure 6.2.2-1 shows the flow path from the passive containment cooling water storage tank leading to the spent fuel pool and the tie-in to the spent fuel pool is also shown in Figure 9.1-6.

The flow from the passive containment cooling water storage tank (PCCWST) to the spent fuel pool, required to provide sufficient makeup to the spent fuel pool to keep the fuel covered as the pool water boils off, is 118 gpm. This is the maximum flow required at the initiation of makeup flow from the PCCWST during the worst case conditions in the pool, which is a full core offload. The makeup flow rate required decreases with time as the decay heat decreases.

After 72 hours, makeup water from the passive containment cooling ancillary water storage tank can either be pumped (with the passive containment cooling recirculation pumps) to the passive

Figure A-12b: Proposed Changes to DCD Section 9.1.3 (Cont'd)

(cont.)

After 72 hours, makeup water from the passive containment cooling ancillary water storage tank can either be pumped (with the passive containment cooling recirculation pumps) to the passive containment cooling water storage tank and then gravity fed to the spent fuel pool as discussed above, or the water can be pumped directly to the spent fuel pool. When the makeup water is pumped directly to the pool, the flow rate is controlled by the same manual throttle valve which is used to set the flow rate when providing gravity driven flow from the passive containment cooling water storage tank.

The flow rates provided from the passive containment cooling ~~auxiliary~~ ancillary water storage tank (PCCAWST) to the spent fuel pool by the recirculation pumps are 35 gpm or 50 gpm. These are the required flow rates to provide sufficient makeup to the spent fuel pool to keep the fuel covered as the pool water boils off~~, is 35 gpm~~. The plant condition associated with ~~this flow~~35 gpm is a loss of power combined with a seismic event when the plant is operating at full power, shortly after startup from a refueling outage. The plant condition associated with 50 gpm is also a loss of power combined with a seismic event but when the plant is being refueled. This refueling scenario considers the time between completion of plant cooldown and just prior to plant startup once the refueling is complete. With a refueling scenario, additional decay heat is located in the spent fuel pool because of the recent offload and enough decay heat remains in the reactor vessel such that the PCCWST is still required for containment cooling and cannot be used for spent fuel pool makeup. ~~This~~ These conditions results in the maximum flow required from the PCCAWST because cooling water must be supplied to both the PCCWST and the spent fuel pool to provide both containment and spent fuel cooling for a period of four days following the initial three days of passive systems operation.

Spent fuel pool level instrumentation is discussed in Subsection 9.1.3.7.

9.1.3.4.3.1 Failure of a Spent Fuel Pool Cooling System Pump

If a spent fuel pool cooling system pump fails when only one pump is operating, an alarm is actuated. Due to the heat capacity of the water in the spent fuel pool, sufficient time exists for the operators to manually align the standby spent fuel pool cooling system train of equipment (pump/heat exchanger) to cool the spent fuel pool.

9.1.3.4.3.2 Leakage from the Spent Fuel Pool Cooling System

The connections from the spent fuel pool cooling system to the pool are such that leakage in the spent fuel pool cooling system will not result in the pool water level falling to unacceptable levels. The heat capacity of the water in the pool is sufficient to allow the operators enough time to locate the leak and repair it. In the most probable scenario, cooling will be maintained by operation of the standby train of equipment. However, if spent fuel pool cooling must be terminated, sufficient time exists to allow for repairs of a leak in the system.

9.1.3.4.3.3 Loss of Offsite Power

The spent fuel pool cooling system pumps can be manually loaded on the respective onsite standby diesel generator in the event of a loss of offsite power. The spent fuel pool cooling system is capable of providing spent fuel pool cooling following this event.

Figure A-12c: Proposed Changes to DCD Section 9.1.3 (Cont'd)

(cont.)

9.1.3.4.3.4 **Station Blackout**

Following a loss of ac power (off-site power and both standby diesel generators), the heat capacity of the water in the pool is such that cooling of the fuel is maintained. Table 9.1-4 provides the times before boiling would occur in the pool following station blackout for various scenarios as well as the minimum levels of water that would be reached. Water vapor that evaporates from the surface of the spent fuel pool is vented to the outside environment through an engineered relief panel. This vent path maintains the fuel handling area at near atmospheric pressure conditions. The doses resulting from spent fuel pool boiling have been calculated and are included in Chapter 15. The release concentrations at the site boundary are small fractions of the limits specified in 10 CFR 20, Appendix B with no credit for removal of activity by building ventilation systems (which are not available during loss of ac power situations). The equipment in the fuel handling area, rail car bay\filter storage area, and spent resin equipment and piping areas exposed to elevated temperature and humidity conditions as a result of pool boiling does not provide safety-related mitigation of the effects of spent fuel pool boiling or station blackout. The fuel handling area, rail car bay, and spent resin area do not have connecting ductwork with other areas of the radioactively controlled area of the auxiliary building and connecting floor drains have a water seal which prevents steam migration. The environment in these other areas during spent fuel pool steaming is mild with respect to safety-related equipment qualification and affords access for post-accident actions.

Spent fuel pool makeup for long term station blackout can be provided through seismically qualified safety-related makeup connections from the passive containment cooling system. These connections are located in an area of the auxiliary building that can be accessed without exposing operating personnel to excessive levels of radiation or adverse environmental conditions during boiling of the pool. Operating personnel are not required to enter the fuel handling area when normal cooling is not available, and are not required to enter the area to recover normal cooling.

9.1.3.4.3.5 **Reactor Coolant System Makeup**

During an event in which the reactor coolant system pressure and inventory decrease the normal residual heat removal system pumps are started to provide makeup water to the reactor coolant system when the primary system pressure is sufficiently reduced for injection to start. The AP1000 procedure for post-accident operation of the normal residual heat removal pumps is that the operators align the pumps to the cask loading pit. This is accomplished by the operator opening a motor operated isolation valve (see subsection 5.4.7.3.3.5) between the cask loading pit and the normal residual heat removal pump suction line. When the water in this pit nears empty, the pump suction is re-aligned to the IRWST/containment recirculation connection so that the pumps can continue to provide injection to the reactor coolant system. The refueling water from the cask loading pit provides additional water into containment (and thus additional driving head) for the post accident containment recirculation. The AP1000 emergency operating procedures will include a restriction on use of this injection method if the gate between the spent fuel pool and the cask loading pit is open at the initiation of the event. In this case the operators will be instructed to close the gate, if possible, before initiating the makeup flow with the normal residual heat removal pumps. Injection from the cask loading pit will only be initiated if the gate can be closed. The gate is normally in the closed position unless cask loading <u>or refueling</u> operations are in progress.

Figure A-12d: Proposed Changes to DCD Section 9.1.3 (Cont'd)

9.1.3.5 Safety Evaluation

The only spent fuel pool cooling system safety-related functions are containment isolation and emergency makeup connections to the spent fuel pool. Containment isolation evaluation is described in subsection 6.2.3. The following provides the evaluation of the design of the spent fuel pool as well as the spent fuel pool cooling system:

- The spent fuel pool is designed such that a water level is maintained above the spent fuel assemblies for at least 7 days following a loss of the spent fuel pool cooling system, using only onsite makeup water (see Table 9.1-4). The minimum water level to achieve sufficient cooling is the subcooled, collapsed level (without vapor voids) required to cover the top of the fuel assemblies.
- The maximum heat load is assumed to be the heat load for a full core off load immediately following a refueling in which 44 percent of the fuel assemblies were replaced.
- Safety-related makeup water can be supplied to the fuel pool from the fuel transfer canal, cask washdown pit, cask loading pit, and passive containment cooling water storage tank.
- The spent fuel pool cooling system includes safety-related connections from the passive containment cooling ~~system~~ water storage tank in the passive containment cooling system to establish safety-related makeup to the spent fuel pool following a design basis event including a seismic event.
- In addition to the safety-related water sources, makeup water is also obtained from the passive containment cooling ~~system~~ ancillary water storage tank. Water from this tank can be pumped by the passive containment cooling system recirculation pumps either to the passive containment cooling water storage tank (and then gravity fed to the spent fuel pool), or directly to the spent fuel pool.

Radiation shielding normally provided by the water above the fuel is not required when normal spent fuel pool cooling is not available. Personnel are not permitted in the area when the level in the pool is below the minimum level.

The acceptability of the design of the spent fuel pool cooling system is based on specific General Design Criteria (GDCs) and Regulatory Guides as described in Sections 3.1 and 1.9.

9.1.3.6 Inspection and Testing Requirements

9.1.3.6.1 Preoperational Testing, Analysis, and Inspection

9.1.3.6.1.1 Pump Flow Capability Testing

Each spent fuel pool cooling system pump will be tested. The flow paths will be aligned for normal spent fuel pool cooling by one train of spent fuel pool cooling system components. The flow delivered to each spent fuel pool cooling system heat exchanger will be measured by a flow instrument at the spent fuel pool cooling system pump discharge. The testing confirms that the pumped flow is equal to or greater than the minimum value shown in Table 9.1-3. This is the

Figure A-12e: Proposed Changes to DCD Section 9.1.3 (Cont'd)

Table 9.1-4

STATION BLACKOUT/SEISMIC EVENT TIMES[1]

Event	Time to Saturation[1] (hours)	Height of Water Above Fuel at 72 Hours[4] (feet)	Height of Water Above Fuel at 7 Days[4] (feet)
Seismic Event[2] – Power Operation Immediately Following a Refueling[7]	7.38~~6.50~~	1.4~~1.6~~[~~6~~]	1.4~~1.6~~[6]
Seismic Event[8] – Refueling, Immediately Following Spent Fuel Region Offload[3][7]	5.59~~4.68~~	4.2~~8.3~~[5]	4.2~~8.3~~[~~6~~5]
Seismic Event[8] – Refueling, Emergency Full Core Off-Load[3] Immediately Following Refueling[7]	2.33~~1.37~~	8.0~~8.3~~[5]	8.0~~8.3~~[6]

Notes:

1. Times calculated neglect heat losses to the passive heat sinks in the fuel area of the auxiliary building.
2. Seismic event assumes water in the pool is initially drained to the level of the spent fuel pool cooling system connection simultaneous with a station blackout. Fuel cooling water sources are spent fuel pool, fuel transfer canal (including gate), and cask washdown pit for 72 hours. Between 72 hours and 7 days fuel cooling water provided from passive containment cooling system ancillary water storage tank.
3. Fuel movement complete, 150 hours after shutdown.
4. See subsection 9.1.3.5 for minimum water level.
5. Alignment of PCS water storage for supply of makeup water permits maintaining pool level at this elevation. Decay heat in reactor vessel is less that 6~~9~~ MW, thus no PCS water is required for containment cooling.
6. Alignment of the PCS ancillary water storage tank and initiation of PCS recirculation pumps provide a makeup water supply to maintain this pool level or higher above the top of the fuel.
7. The number of fuel assemblies refueled has been conservatively established to include the worst case between an 18-month fuel cycle plus 5 defective fuel assemblies (69 total assemblies or 44% of the core) and a 24-month fuel cycle plus 5 defective fuel assemblies (77 total assemblies or 49% of the core).
8. Seismic event assumes water in the pool is initially drained to the level of the spent fuel pool cooling system connection simultaneous with a station blackout. Fuel cooling water sources are spent fuel pool, fuel transfer canal (including gate), cask washdown pit, cask loading pit, and passive containment cooling system water storage tank for 72 hours~~7 days~~.
9. A minimum of 18 hours is available for operator action to align makeup water to the spent fuel pool after a seismic event.

Figure A-13: Proposed Changes to DCD Section 9.1.4

Table 16.3-2 (Cont.)

INVESTMENT PROTECTION SHORT-TERM AVAILABILITY CONTROLS

2.0 Plant Systems

2.5 PCCWST and Spent Fuel Pool Makeup - Long Term Shutdown

BASES:

The PCS recirculation pumps provide long-term shutdown support by transferring water from the PCS ancillary tank to the PCCWST and the spent fuel pool. The specified PCS ancillary water tank volume is sufficient to maintain PCS and Spent Fuel Pool cooling during the 3 to 7 day time period following an accident. After 7 days, water brought in from offsite allows the PCCWST to continue to provide PCS cooling and makeup to the spent fuel pit. This PCCWST makeup function is important because it supports long-term shutdown operation. A minimum availability of 90% is assumed for this function during the MODES of applicability, considering both maintenance unavailability and failures to operate.

The PCCWST makeup function involves the use of one PCS recirculation pump, the PCS ancillary tank and the line connecting the PCS ancillary tank with the PCCWST and spent fuel pool. One PCS recirculation pump normally operates to recirculate the PCCWST. DCD subsections 6.2.2 and 9.1.3 contain additional information on the PCCWST and spent fuel pool makeup function.

The PCCWST makeup function should be available during MODES of operation when PCS and spent fuel pool cooling is required; one PCS recirculation pump and PCS ancillary tank should be available during all MODES.

Planned maintenance should be performed on the redundant pump (ie the pump not required to be available). Planned maintenance affecting the PCS ancillary tank that requires less than 72 hours to perform can be performed in any MODE of operation. Planned maintenance requiring more than 72 hours should be performed in MODES 5 or 6 when the calculated core decay heat is ≤ 6 ~~9~~ MWt. The bases for this recommendation is that the long-term PCS makeup is not required in this condition, and in most cases, the PCCWST can provide the required makeup to the spent fuel pool.

Figure A-14: Proposed Changes to DCD Section 16.3

Table 3.3.2-1 (page 2 of 13)
Engineered Safeguards Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE	TRIP SETPOINT
2. Core Makeup Tank (CMT) Actuation						
a. Manual Initiation	$1,2,3,4^{(j)}$	2 switches	E,N	SR 3.3.2.3	NA	NA
	$4^{(n)}, 5^{(i)}$	2 switches	E,U	SR 3.3.2.3	NA	NA
b. Pressurizer Water Level – Low 2	$1,2,3,4^{(j)}$	4	B,N	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≥ 9.95% span ≤ 10.05% span	10% span
	$4^{(n)}, 5^{(i)}$	4	B,V	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≥ 9.95% span ≤ 10.05% span	10% span
c. Safeguards Actuation	$1,2,3,4,5^{(i)}$	Refer to Function 1 (Safeguards Actuation) for initiating functions and requirements.				
d. ADS Stages 1, 2, & 3 Actuation	$1,2,3,4,5^{(i)}$	Refer to Function 9 (ADS Stages 1, 2 & 3 Actuation) for all initiating functions and requirements.				
3. Containment Isolation						
a. Manual Initiation	1,2,3,4	2 switches	E,O	SR 3.3.2.3	NA	NA
	$5^{(m)}, 6^{(m)}$	2 switches	G,Y	SR 3.3.2.3	NA	NA
b. Manual Initiation of Passive Containment Cooling	$1,2,3,4,5^{(e,m)}, 6^{(e,m)}$	Refer to Function 12.a (Passive Containment Cooling Actuation) for initiating functions and requirements.				
c. Safeguards Actuation	$1,2,3,4,5^{(m)}$	Refer to Function 1 (Safeguards Actuation) for initiating functions and requirements.				

(e) With decay heat > ~~9.0~~6.0 MWt.

(i) With the RCS pressure boundary intact.

(j) With the RCS not being cooled by the Normal Residual Heat Removal System (RNS).

(m) Not applicable for valve isolation Functions whose associated flow path is isolated.

(n) With the RCS being cooled by the RNS.

Figure A-15a: Proposed Changes to DCD Table 16.3.3.2-1

Table 3.3.2-1 (page 7 of 13)
Engineered Safeguards Actuation System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS	CONDITIONS	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE	TRIP SETPOINT
11. Reactor Coolant Pump Trip						
a. ADS Stages 1, 2 & 3 Actuation	Refer to Function 9 (ADS Stages 1, 2 & 3 Actuation) for initiating functions and requirements.					
b. Reactor Coolant Pump Bearing Water Temperature – High	1,2	4 per RCP	B,L	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≤ 190.4°F	190°F
c. Manual CMT Actuation	Refer to Function 2.a (Manual CMT Actuation) for requirements.					
d. Pressurizer Water Level – Low 2	1,2,3,4$^{(j)}$	4	B,N	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≥ 9.95% span ≤ 10.05% span	10% span
	4$^{(n)}$,5$^{(c,j)}$	4	B,V	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≥ 9.95% span ≤ 10.05% span	10% span
e. Safeguards Actuation	Refer to Function 1 (Safeguards Actuation) for initiating functions and requirements.					
12. Passive Containment Cooling Actuation						
a. Manual Initiation	1,2,3,4	2 switches	E,O	SR 3.3.2.3	NA	NA
	5$^{(e)}$,6$^{(e)}$	2 switches	G,Y	SR 3.3.2.3	NA	NA
b. Containment Pressure – High 2	1,2,3,4	4	B,O	SR 3.3.2.1 SR 3.3.2.4 SR 3.3.2.5 SR 3.3.2.6	≤ 6.21 psig	6.2 psig

(c) With pressurizer level ≥ 20%.

(e) With decay heat > ~~9.0~~6.0 MWt.

(j) With the RCS not being cooled by the Normal Residual Heat Removal System (RNS).

(n) With the RCS being cooled by the RNS.

Figure A-15b: Proposed Changes to DCD Table 16.3.3.2-1 (Cont'd)

Table 3.3.5-1 (page 1 of 1)
DAS Manual Controls

	FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CONTROLS
1.	Reactor trip manual controls	1,2	2 switches
2.	PRHR HX control and IRWST gutter control valves	1,2,3,4,5(a)	2 switches
3.	CMT isolation valves	1,2,3,4,5(a)	2 switches
4.	ADS stage 1 valves	1,2,3,4,5(a)	2 switches
5.	ADS stage 2 valves	1,2,3,4,5(a)	2 switches
6.	ADS stage 3 valves	1,2,3,4,5(a)	2 switches
7.	ADS stage 4 valves	1,2,3,4,5,6(c)	2 switches
8.	IRWST injection squib valves	1,2,3,4,5,6	2 switches
9.	Containment recirculation valves	1,2,3,4,5,6	2 switches
10.	Passive containment cooling drain valves	1,2,3,4,5(b),6(b)	2 switches
11.	Selected containment isolation valves	1,2,3,4,5,6	2 switches

(a) With RCS pressure boundary intact.

(b) With the calculated reactor decay heat > 9.06.0 MWt.

(c) In MODE 6 with reactor internals in place.

Figure A-16: Proposed Changes to DCD Table 16.3.3.5-1

3.6 CONTAINMENT SYSTEMS

3.6.7 Passive Containment Cooling System (PCS) – Shutdown

LCO 3.6.7 The passive containment cooling system shall be OPERABLE with all three water flow paths OPERABLE.

APPLICABILITY: MODE 5 with the calculated reactor decay heat > ~~9.0~~6.0 MWt,
MODE 6 with the calculated reactor decay heat > ~~9.0~~6.0 MWt.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One passive containment cooling water flow path inoperable.	A.1	Restore flow path to OPERABLE status.	7 days
B. Two passive containment cooling water flow paths inoperable.	B.1	Restore flow paths to OPERABLE status.	72 hours
C. One or more water storage tank parameters (temperature and volume) not within limits.	C.1	Restore water storage tank to OPERABLE status.	8 hours

Figure A-17: Proposed Changes to DCD Section 16.3.6.7

3.7 PLANT SYSTEMS

3.7.9 Fuel Storage Pool Makeup Water Sources

LCO 3.7.9 Fuel storage pool makeup water sources shall be OPERABLE.

- NOTES -

1. OPERABILITY of the cask washdown pit is required when the calculated spent fuel storage pool decay heat ≥ 4.6 MWt and ≤ 5.47.2 MWt, and with the calculated reactor decay heat > 9 MWt.

2. OPERABILITY of the cask loading pit is required when the calculated spent fuel storage pool decay heat > 5.6 MWt and ≤ 7.2 MWt.

23. OPERABILITY of the passive containment cooling water sourcePCCWST is required as a spent fuel storage pool makeup water source when the calculated spent fuel storage pool decay heat > 5.47.2 MWt. If the reactor decay heat is > 6.0 MWt, the PCCWST must be exclusively available for containment cooling in accordance with LCO 3.6.7.

APPLICABILITY: During storage of fuel in the spent fuel storage pool with a calculated decay heat ≥ 4.6 MWt.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more Rrequired spent fuel storage pool makeup water sources inoperable.	A.1 ----- **- NOTE -** LCOs 3.0.3 and 3.0.8 are not applicable. ----- Initiate action to restore the required makeup water source(s) to OPERABLE status.	Immediately

Figure A-18a: Proposed Changes to DCD Section 16.3.7.9

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.7.9.1	- NOTE - Only required to be performed when spent fuel storage pool calculated decay heat is > 7.2 MWt. Verify one passive containment cooling system, motor-operated valve in each flow path is closed and locked, sealed, or otherwise secured in position.	7 days
SR 3.7.9.24	- NOTE - Only required to be performed when spent fuel storage pool calculated decay heat is > 7.2 MWt. Verify the passive containment cooling system water storage tankPCCWST volume is ≥ 400,000 gallons.	7 days
SR 3.7.9.32	- NOTE - Only required to be performed when spent fuel storage pool calculated decay heat is ≤ 7.2 MWt. Verify the water level in the cask washdown pit is ≥ 13.75 ft and in communication with the spent fuel storage pool.	3031 days
SR 3.7.9.4	- NOTE - Only required to be performed when spent fuel storage pool calculated decay heat is > 5.6 MWt and ≤ 7.2 MWt. Verify the water level in the cask loading pit is ≥ 43.9 ft. and in communication with the spent fuel storage pool.	31 days

Figure A-18b: Proposed Changes to DCD Section 16.3.7.9 (Cont'd)

SURVEILLANCE REQUIREMENTS

SR 3.7.9.53	Verify the spent fuel storage pool makeup isolation valves PCS-PL-V009, PCS-PL-V045, PCS-PL-V051, SFS-PL-V042, SFS-PL-V045, SFS-PL-V049, SFS-PL-V066, and SFS-PL-V068 are OPERABLE in accordance with the Inservice Testing Program.	In accordance with the Inservice Testing Program

Figure A-18c: Proposed Changes to DCD Section 16.3.7.9 (Cont'd)

Table B 3.0-1 (page 1 of 1)
Passive Systems Shutdown MODE Matrix

LCO Applicability	Automatic Depressurization System	Core Makeup Tank	Passive RHR	IRWST	Containment	Containment Cooling[(1)]
MODE 5 RCS pressure boundary intact	9 of 10 paths OPERABLE All paths closed LCO 3.4.12	One CMT OPERABLE LCO 3.5.3	System OPERABLE LCO 3.5.5	One injection flow path and one recirculation sump flow path OPERABLE LCO 3.5.7	Closure capability LCO 3.6.8	Three water flow paths OPERABLE LCO 3.6.7
Required End State	MODE 5 RCS pressure boundary open, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary open, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary open, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level
MODE 5 RCS pressure boundary open or pressurizer level < 20%	Stages 1, 2, and 3 open 2 stage 4 valves OPERABLE LCO 3.4.13	None	None	One injection flow path and one recirculation sump flow path OPERABLE LCO 3.5.7	Closure capability LCO 3.6.8	Three water flow paths OPERABLE LCO 3.6.7
Required End State	MODE 5 RCS pressure boundary open, ≥ 20% pressurizer level			MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level	MODE 5 RCS pressure boundary intact, ≥ 20% pressurizer level
MODE 6 Upper internals in place	Stages 1, 2, and 3 open 2 stage 4 valves OPERABLE LCO 3.4.13	None	None	One injection flow path and one recirculation sump flow path OPERABLE LCO 3.5.8	Closure capability LCO 3.6.8	Three water flow paths OPERABLE LCO 3.6.7
Required End State	MODE 6 Upper internals removed			MODE 6 Refueling cavity full	MODE 6 Refueling cavity full	MODE 6 Refueling cavity full
MODE 6 Upper internals removed	None	None	None	One injection flow path and one recirculation sump flow path OPERABLE LCO 3.5.8	Closure capability LCO 3.6.8	Three water flow paths OPERABLE LCO 3.6.7
Required End State				MODE 6 Refueling cavity full	MODE 6 Refueling cavity full	MODE 6 Refueling cavity full

(1) Containment cooling via PCS is not required when core decay heat < 96 MWt.

Figure A-19: Proposed Changes to DCD Table 16 B 3.0-1

APPLICABLE SAFETY ANALYSES, LCOs, and APPLICABILITY (continued)

2.c. Safeguards Actuation (Function 1)

CMT Valve Actuation is also initiated by all Functions that initiate the Safeguards Actuation signal. The CMT Valve Actuation Function requirements are the same as the requirements for the Safeguards Actuation Functions, but only apply in MODES 1 through 4, and in MODE 5 with the RCS pressure boundary intact. Therefore, the requirements are not repeated in Table 3.3.2-1. Instead, Function 1 is referenced for all initiating Functions and requirements.

2.d. ADS Stages 1, 2, and 3 Actuation (Function 9)

The CMTs are actuated on an ADS Stages 1, 2, and 3 actuation. The CMT Actuation Function requirements are the same as the requirements for the ADS Stages 1, 2, and 3 Actuation Function, but only apply in MODES 1 through 4, and in MODE 5 with the RCS pressure boundary intact. Therefore, the requirements are not repeated in Table 3.3.2-1. Instead, Function 9 is referenced for all initiating functions and requirements.

3. Containment Isolation

Containment Isolation provides isolation of the containment atmosphere and selected process systems which 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.

Containment Isolation is actuated by the Safeguards Actuation signal, manual actuation of containment cooling, or manually.

Manual and automatic initiation of Containment Isolation must be OPERABLE in MODES 1, 2, 3, and 4, when containment integrity is required. Manual initiation is required in MODE 5 and MODE 6 for closure of open penetrations providing direct access from the containment atmosphere to the outside atmosphere. Manual initiation of this Function in MODES 5 and 6 is not applicable if the direct access lines penetrating containment are isolated. Initiation of containment isolation by manual initiation of passive containment cooling in MODE 5 or 6 with decay heat ≤ ~~9.0~~6.0 MWt is not required because OPERABILITY of the passive containment cooling system is not required when air cooling is sufficient. This provides the capability to

Figure A-20a: Proposed Changes to DCD Section 16 B 3.3.2

APPLICABLE SAFETY ANALYSES, LCOs, and APPLICABILITY (continued)

The LCO requires this Function to be OPERABLE in MODES 1, 2, 3, and 4 when the potential exists for a DBA that could require the operation of the Passive Containment Cooling System. In MODES 5 and 6, with decay heat more than ~~9.0~~<u>6.0</u> MWt, manual initiation of the PCS provides containment heat removal. Section B 3.6.7, Applicability, provides the basis for the decay heat limit.

12.a. <u>Manual Initiation</u>

The operator can initiate Containment Cooling at any time from the main control room by actuating either of the two containment cooling actuation switches. There are two switches in the main control room, either of which will actuate containment cooling in all divisions. Manual Initiation of containment cooling also actuates containment isolation.

12.b. <u>Containment Pressure – High 2</u>

This signal provides protection against a LOCA or SLB inside containment. Four channels are provided to permit one channel to be in trip or bypass indefinitely and still ensure no single random failure will disable this trip Function.

The transmitters and electronics are located inside containment, thus, they will experience harsh environmental conditions and the trip setpoint reflects only steady state instrument uncertainties associated with the containment environment. The Containment Pressure – High 2 setpoint has been specified as low as reasonable, without creating potential for spurious trips during normal operations, consistent with the TMI action item (NUREG-0933, Item II.E.4.2) guidance.

13. <u>PRHR Heat Exchanger Actuation</u>

The PRHR Heat Exchanger (HX) provides emergency core decay heat removal when the Startup Feedwater System is not available to provide a heat sink. PRHR is actuated when the discharge valves are opened in response to Steam Generator Narrow Range (NR) Level – Low coincident with Startup Feedwater Flow – Low, Steam Generator Wide Range (WR) Level – Low, ADS Stages 1, 2, and 3 Actuation, CMT Actuation, Pressurizer Water Level – High 3, or Manual Initiation.

Figure A-20b: Proposed Changes to DCD Section 16 B 3.3.2 (Cont'd)

BASES

APPLICABILITY

OPERABILITY of the PCS is required in either MODE 5 or 6 with the calculated reactor decay heat greater than ~~9~~6 MWt for heat removal in the event of a loss of nonsafety decay heat removal capabilities.

With the decay heat less than ~~9~~6 MWt, the decay heat can be ~~easily~~ removed from containment with air cooling alone. Confirmation of decay heat levels may be determined consistent with the assumptions and analysis basis of ANS 1979 plus 2 sigma or via an energy balance of the reactor coolant system.

The PCS requirements in MODES 1, 2, 3, and 4 are specified in LCO 3.6.6, "Passive Containment Cooling System (PCS) – Operating."

ACTIONS

A.1

With one passive containment cooling water flow path inoperable, the affected flow path must be restored within 7 days. In this degraded condition, the remaining flow paths are capable of providing greater than 100% of the heat removal needs after an accident, even considering the worst single failure. The 7 day Completion Time was chosen in light of the remaining heat removal capability and the low probability of a DBA occurring during this period.

B.1

With two passive containment cooling water flow paths inoperable, at least one affected flow path must be restored to OPERABLE status within 72 hours. In this degraded condition, the remaining flow path is capable of providing greater than 100% of the heat removal needs after an accident. The 72 hour Completion Time was chosen in light of the remaining heat removal capability and the low probability of an event occurring during this period.

C.1

If the cooling water tank is inoperable, it must be restored to OPERABLE status within 8 hours. The tank may be declared inoperable due to low water volume or temperature out of limits. The 8 hour Completion Time is reasonable based on the remaining heat removal capability of the system and the availability of cooling water from alternate sources.

D.1.1, D.1.2, and D.2

Action must be initiated if any of the Required Actions and associated Completion Times are not met, or if the LCO is not met for reasons other than Condition A, B, or C. If in MODE 5 with the RCS pressure boundary

Figure A-21: Proposed Changes to DCD Section 16 B 3.6.7

B 3.7 PLANT SYSTEMS

B 3.7.9 Fuel Storage Pool Makeup Water Sources

BASES

BACKGROUND

The spent fuel storage pool is normally cooled by the nonsafety spent fuel pool cooling system. In the event the normal cooling system is unavailable, the spent fuel storage pool can be cooled by the normal residual heat removal system. Alternatively, the spent fuel storage pool contains sufficient water inventory for decay heat removal by boiling. To support extended periods of loss of normal pool cooling, makeup water is required to provide additional cooling by boiling. Both safety and non-safety makeup water sources are available on-site.

~~Two~~ Three safety-related, gravity fed sources of makeup water are provided to the spent fuel storage pool. These makeup water sources contain sufficient water to maintain spent fuel storage pool cooling for 72 hours. ~~The containment cooling system water storage tank provides makeup water when pool decay heat is > 5.4 MWt and the decay heat in the reactor is less than 9.0 MWt.~~ When the spent fuel storage pool decay heat is > 4.7 MWt and ≤ 7.2 MWt, the cask washdown pit must be available to provide makeup to the spent fuel storage pool. When the spent fuel storage pool decay heat is > 5.6 MWt and ≤ 7.2 MWt, both t~~T~~he cask washdown pit and the cask loading pit must be available to provide makeup to the spent fuel storage pool. ~~provides makeup water when decay heat in the pool is ≥ 4.6 MWt and ≤ 5.4 MWt.~~ When the spent fuel storage pool decay heat is > 7.2 MWt and the reactor decay heat is ≤ 6.0 MWt, the PCCWST must be available to provide makeup water to the spent fuel storage pool (when the tank is no longer required for containment cooling purposes). Additional on-site makeup water sources are available to provide spent fuel storage pool cooling between 3 and 7 days.

The PCCWST ~~containment cooling system water storage tank~~ is isolated by two normally closed valves. The normally closed valves will be opened only to provide emergency makeup to the spent fuel storage pool. A third downstream valve permits the operator to regulate addition of water to the spent fuel storage pool as required to maintain the cooling water inventory.

Once decay heat in the spent fuel storage pool is reduced to below 4.6 MWt, the spent fuel storage pool water inventory is sufficient, without makeup, to maintain the spent fuel storage pool for 72 hours. When the spent fuel storage pool decay heat load is ~~reduced below 4.6~~≤ 5.6 MWt for the cask loading pit and ≤ 4.7 MWt for the cask washdown pit, the pits are no longer required to be OPERABLE for spent fuel storage pool makeup~~may be drained and returned to use for shipping cask cleaning~~

Figure A-22a: Proposed Changes to DCD Section 16 B 3.7.9

~~operations~~.

A general description of the spent fuel storage pool design is given in Section 9.1.2 (Ref. 1). A description of the Spent Fuel Pool Cooling and Cleanup System is given in Section 9.1.3 (Ref. 2).

BASES

APPLICABLE SAFETY ANALYSES

In the event the normal spent fuel storage pool cooling system is unavailable, the spent fuel cooling is provided by the heat capacity of the water in the pool. The worst case decay heat load (decay heat > ~~5.4~~7.2 MWt) is produced by an emergency full core off-load following a refueling plus ten years of spent fuel. For this case the spent fuel storage pool inventory provided by the water over the stored fuel and below the pump suction connection is capable of cooling the spent fuel storage pool without boiling for at least 2.5 hours, following a loss of normal spent fuel storage pool cooling. After boiling starts, makeup water may be required to replace water lost by boiling and is available, without offsite support, via the ~~passive containment cooling water storage tank~~PCCWST.

The requirements of LCO 3.6.6, "Passive Containment Cooling System – Operating," are applicable in MODES 1, 2, 3, and 4 and LCO 3.6.7, "Passive Containment Cooling System – Shutdown," are applicable in MODES 5 and 6 with reactor decay heat > ~~9.0~~6.0 MWt. LCOs 3.6.6 and 3.6.7 require availability of the containment cooling water tank for containment heat removal. Below ~~9.0~~6.0 MWt reactor decay heat, containment air cooling is adequate. ~~Since there are no design conditions which result in both reactor decay heat > 9.0 MWt and spent fuel storage pool decay heat > 5.4 MWt, the applicability for LCOs 3.6.6/3.6.7 and for LCO 3.7.9 are mutually exclusive.~~

Since none of the Chapter 15 Design Basis Accident analyses assume availability of the PCCWST~~containment cooling water tank~~, ~~or the~~ cask washdown pit, or the cask loading pit for spent fuel storage pool makeup, the spent fuel storage pool makeup water sources specification does not satisfy any of the 10 CFR 50.36(c)(2)(ii) criteria. This LCO is included in accordance with NRC guidance provided in an NRC letter (Reference 3).

LCO

The spent fuel storage pool makeup water sources are required to contain the following amount of water to be considered OPERABLE:

- the cask washdown pit water level must be ≥ 13.75 ft
- cask loading pit water level must be ≥ 43.9 ft
- PCCWST~~containment cooling water tank~~ ~~are~~ is required to contain ≥ 400,000 gallons of water~~, respectively~~.

A-22b: Proposed Changes to DCD Section 16 B 3.7.9 (Cont'd)

BASES

An OPERABLE flow path from the required makeup source assures spent fuel cooling for at least 72 hours. Several additional makeup sources are available, including the ground level PCCAWST~~containment cooling ancillary water storage tank~~. These makeup sources assure spent fuel cooling for at least 7 days.

Note 1 specifies that ~~either~~ the cask washdown pit ~~or the passive containment cooling water storage tank~~ is required to be OPERABLE when the spent fuel storage pool decay heat ≥ 4.6 MWt and ≤ ~~5.4~~7.2 MWt.

Note 2 specifies that cask loading pit is required to be OPERABLE when the spent fuel storage pool decay heat > 5.6 MWt and ≤ 7.2 MWt.

Note ~~2~~3 specifies that the ~~passive containment cooling water storage tank source~~PCCWST is required to be OPERABLE when the spent fuel storage pool decay heat is > ~~5.4~~7.2 MWt, which is normal following a full core off load. The larger makeup source is necessary for the higher decay heat load. In MODE 5 and 6, with the calculated reactor decay heat > 6.0 MWt, the PCCWST is reserved for containment cooling in accordance with LCO 3.6.7, Passive Containment Cooling System (PCS) – Shutdown. Thus, fuel movement from the reactor to the spent fuel storage pool must be suspended until reactor decay heat ≤ 6.0 MWt, if the fuel movement will increase the spent fuel storage pool decay heat to > 7.2 MWt.

When a portion of the fuel is returned to the reactor vessel in preparation for startup, the pool decay heat is reduced to ≤ 5.4 MWt and makeup from the cask washdown pit is sufficient.

APPLICABILITY

This LCO applies during storage of fuel in the spent fuel storage pool with a calculated decay heat ≥ 4.6 MWt. With decay heat < 4.6 MWt, the assumed spent fuel storage pool water inventory (i.e., level below the pump suction connection to the pool) provides for 3 days of cooling without makeup.

ACTIONS

LCO 3.0.3 is applicable while in MODE 1, 2, 3, or 4. Since spent fuel pool cooling requirements apply at all times, the ACTIONS have been modified by a Note stating that LCO 3.0.3 is not applicable. Spent fuel pool cooling requirements are independent of reactor operations. Entering LCO 3.0.3 while in MODE 1, 2, 3, or 4 would require the unit to be shutdown unnecessarily.

LCO 3.0.8 is applicable while in MODE 5 or 6. Since spent fuel pool cooling requirements apply at all times, the ACTIONS have been modified by a Note stating that LCO 3.0.8 is not applicable. Spent fuel pool cooling

A-22c: Proposed Changes to DCD Section 16 B 3.7.9 (Cont'd)

requirements are independent of shutdown reactor operations. Entering LCO 3.0.8 while in MODE 5 or 6 would require the optimization of plant safety, unnecessarily.

A.1

If ~~the passive containment cooling water storage tank (with decay heat > 5.4 MWt) and/or~~ the cask washdown pit (with spent fuel storage pool decay heat ≥ 4.6 and ≤ ~~5.4~~7.2 MWt), the cask loading pit (with spent fuel storage pool decay heat > 5.6 MWt and ≤ 7.2 MWt) or the PCCWST (with spent fuel storage pool decay heat > 7.2 MWt) is inoperable, Action must be initiated immediately to restore the makeup source or its associated flow path to OPERABLE status.

Additionally, in order to provide the maximum cooling capability, the spent fuel pool should be filled to its maximum level. Nonsafety related makeup sources can be used to fill the pool. This action is not specified in the specification, since the benefit of adding approximately 6 inches of water to the pool is less than a 5% improvement in cooling capability.

Figure A-22d: Proposed Changes to DCD Section 16 B 3.7.9 (Cont'd)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.7.9.1

This SR verifies that the three flow paths from the PCCWST to the containment vessel are isolated and secured to prevent inadvertent opening and loss of required tank volume. The verification is required to be performed prior to declaring the PCCWST OPERABLE for spent fuel storage pool usage.

The 7 day Frequency is appropriate because the valves in the passive containment cooling system are controlled by plant procedures.

SR 3.7.9.21

This SR verifies sufficient passive containment cooling system water storage tankPCCWST volume is available in the event of a loss of spent fuel cooling prior to declaring the tank OPERABLE for spent fuel storage pool usage.

The 7 day Frequency is appropriate because the volume in the passive containment cooling system water storage tankPCCWST is normally stable and water level changes are controlled by plant procedures.

SR 3.7.9.32

This SR verifies sufficient cask washdown pit water volume is available in the event of a loss of spent fuel cooling. The 13.75 ft level specified provides makeup water for stored fuel with decay heat ≥ 4.6 and ≤ 5.47.2 MWt. The cask washdown pit is no longer required when the PCCWST is OPERABLE for spent fuel storage pool usage.

The 3031 day Frequency is appropriate because the cask washdown pit has only one drain line which is isolated by series manual valves which are only operated in accordance with plant procedures, thus providing assurance that inadvertent level reduction is not likely.

SR 3.7.9.4

This SR verifies sufficient cask loading pit water volume is available in the event of a loss of spent fuel cooling. The 43.9 ft level specified provides makeup water for stored fuel with decay heat > 5.6 and ≤ 7.2 MWt. The cask loading pit is no longer required when the PCCWST is OPERABLE for spent fuel storage pool usage.

The 31 day Frequency is appropriate because the cask loading pit has only one drain line which is isolated by series manual valves which are only operated in accordance with plant procedures, thus providing assurance that inadvertent level reduction is not likely.

Figure A-22e: Proposed Changes to DCD Section 16 B 3.7.9 (Cont'd)

BASES

SR 3.7.9.5~~3~~

This SR requires verification of the OPERABILITY of the manual makeup water source isolation valves in accordance with the requirements and Frequency specified in the Inservice Testing Program. Manual valves PCS-PL-V009, PCS-PL-V045, PCS-PL-V051, isolate the makeup flow path from the ~~passive containment cooling system water storage tank~~PCCWST. Manual valves SFS-PL-V042, SFS-PL-V045, SFS-PL-V049, SFS-PL-V066, and SFS-PL-V068 isolate the makeup flow path from the cask washdown pit.

REFERENCES

1. Section 9.1.2, "Spent Fuel Storage."
2. Section 9.1.3, "Spent Fuel Pool Cooling System."
3. NRC letter, William C. Huffman to Westinghouse Electric Corporation, "Summary of Telephone Conference with Westinghouse to Discuss Proposed Design Changes to the AP600 Main Control Room Habitability System," dated September 11, 1997.

Figure A-22f: Proposed Changes to DCD Section 16 B 3.7.9 (Cont'd)