ArevaEPRDCPEm Resource

From: HOTTLE Nathan (AREVA) [Nathan.Hottle@areva.com]
Sent: Thursday, September 05, 2013 3:30 PM
To: Snyder, Amy
Cc: Buckberg, Perry; GUCWA Len (EXTERNAL AREVA); UYEDA Graydon (AREVA); LEIGHLITER John (AREVA); RANSOM Jim (AREVA); RYAN Tom (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 541 (6322), FSAR Ch. 2 - NEW PHASE 4 RAI. Question 02-3, Supplement 1
Attachments: RAI 541 Supplement 1 Response US EPR DC - PUBLIC.pdf

Amy,

AREVA NP Inc. provided a schedule for the response to the one question in RAI 541 on April 18, 2012.

The attached file, “RAI 541 Supplement 1 Response US EPR DC - PUBLIC.pdf,” provides a final response to Question RAI 541 - 02-3. Because the response file contains security-related sensitive information that should be withheld from public disclosure in accordance with 10 CFR 2.390, a public version is provided with the security-related sensitive information redacted. This email and attached file do not contain any security-related information. An un-redacted security-related version is provided under separate email.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to Question RAI 541 - 02-3.

The following table indicates the pages in the response document, “RAI 541 Supplement 1 Response US EPR DC - PUBLIC.pdf” that contain AREVA NP’s final response to the subject question.

Question #	Start Page	End Page
RAI 541 — 02-3	2	4

This concludes the formal AREVA NP response to RAI 541, and there are no questions from this RAI for which AREVA NP has not provided responses.

Sincerely,

Nathan Hottle
AREVA Inc.
3315 Old Forest Road
Lynchburg, VA 24501
Phone 434-832-3864
Mobile 434-485-4239
nathan.hottle@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, April 18, 2012 8:08 AM
To: Getachew.Tesfaye@nrc.gov
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 541 (6322), FSAR Ch. 2 - NEW PHASE 4 RAI

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 541 Response US EPR DC.pdf," provides a schedule since a technically correct and complete response to the one question cannot be provided at this time.

The following table indicates the respective pages in the response document, "RAI 541 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 541 — 02-3	2	3

The schedule for a technically correct and complete response to this question is provided below.

Question #	Response Date
RAI 541 — 02-3	July 16, 2013

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Wednesday, March 21, 2012 8:36 AM
To: ZZ-DL-A-USEPR-DL
Cc: Harvey, Brad; Hatchett, Gregory; Ford, Tanya; Segala, John; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 541 (6322), FSAR Ch. 2 - NEW PHASE 4 RAI

Attached please find the subject request for additional information (RAI). A draft of the RAI was provided to you on March 2, 2012, and on March 16, 2012, you informed us that the RAI is clear and no further clarification is needed. As a result, no change is made to the draft RAI. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye

Sr. Project Manager
NRO/DNRL/LB1
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 4674

Mail Envelope Properties (8D35DF68A379A34E8526B758FDCFC04218646D)

Subject: Response to U.S. EPR Design Certification Application RAI No. 541 (6322), FSAR Ch. 2 - NEW PHASE 4 RAI. Question 02-3, Supplement 1
Sent Date: 9/5/2013 3:30:18 PM
Received Date: 9/5/2013 3:30:32 PM
From: HOTTLE Nathan (AREVA)

Created By: Nathan.Hottle@areva.com

Recipients:
"Buckberg, Perry" <Perry.Buckberg@nrc.gov>
Tracking Status: None
"GUCWA Len (EXTERNAL AREVA)" <Len.Gucwa.ext@areva.com>
Tracking Status: None
"UYEDA Graydon (AREVA)" <Graydon.Uyeda@areva.com>
Tracking Status: None
"LEIGHLITER John (AREVA)" <John.Leighliter@areva.com>
Tracking Status: None
"RANSOM Jim (AREVA)" <James.Ransom@areva.com>
Tracking Status: None
"RYAN Tom (AREVA)" <Tom.Ryan@areva.com>
Tracking Status: None
"DELANO Karen (AREVA)" <Karen.Delano@areva.com>
Tracking Status: None
"ROMINE Judy (AREVA)" <Judy.Romine@areva.com>
Tracking Status: None
"Snyder, Amy" <Amy.Snyder@nrc.gov>
Tracking Status: None

Post Office: FUSLYNCMX03.fdom.ad.corp

Files	**Size**	**Date & Time**
MESSAGE	4028	9/5/2013 3:30:32 PM
RAI 541 Supplement 1 Response US EPR DC - PUBLIC.pdf	549706	

Options
Priority: Standard
Return Notification: No
Reply Requested: No
Sensitivity: Normal
Expiration Date:
Recipients Received:

Response to

Request for Additional Information No. 541(6322), Revision 0, Supplement 1

3/17/2012

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 02 - Site Characteristics and Site Parameters
Application Section: FSAR Tier 1, Section 5.0; FSAR Tier 2, Sections 2.0, 2.3, 3.2.2, 3.5.1.4, 3.5.3, 3.8.1, 3.8.3, 3.8.4, 3.8.5

QUESTIONS for Siting and Accident Conseq Branch (RSAC)

Question 02-3:

OPEN ITEM

New Phase 4 RAI

10 CFR 52.47(a)(1) states that the FSAR for an application for a standard design certification must contain the site parameters postulated for the design and an analysis and evaluation of the design in terms of those site parameters, where site parameters are defined in 10 CFR 52.2(a) as the postulated physical, environmental and demographic features of an assumed site. 10 CFR Part 50, Appendix A, GDC 2 requires that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety functions. 10 CFR Part 50, Appendix A, GDC 4 requires that SSCs that are important to safety be appropriately protected against the effects of missiles that may result from events and conditions outside the nuclear power unit.

Nuclear power plants must be designed so that they remain in a safe condition under extreme meteorological events, including those that could result in the most extreme wind events (tornadoes and hurricanes) that could reasonably be predicted to occur at the site. Initially, the U.S. Atomic Energy Commission (predecessor to the NRC) considered tornadoes to be the bounding extreme wind events and issued RG 1.76, ‘‘Design-Basis Tornado for Nuclear Power Plants,’’ in April 1974. The design-basis tornado wind speeds were chosen so that the probability that a tornado exceeding the design basis would occur was on the order of 10^{-7} per year per nuclear power plant. In March 2007, the NRC issued Revision 1 of RG 1.76, ‘‘Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants.” Revision 1 of RG 1.76 relied on the Enhanced Fujita Scale, which was implemented by the National Weather Service in February 2007. The Enhanced Fujita Scale is a revised assessment relating tornado damage to wind speed, which resulted in a decrease in design-basis tornado wind speed criteria in Revision 1 of RG 1.76. Since design-basis tornado wind speeds were decreased as a result of the analysis performed to update RG 1.76, it was no longer clear that the revised tornado design basis wind speeds would bound design-basis hurricane wind speeds in all areas of the United States. This prompted an investigation into extreme wind gusts during hurricanes and their relation to design basis hurricane wind speeds, which resulted in issuing RG 1.221, “Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants,” in October 2011.

RG 1.221 also evaluated missile velocities associated with several types of missiles considered for different hurricane wind speeds. The hurricane missile analyses presented in RG 1.221 are based on missile aerodynamic and initial condition assumptions that are similar to those used for the analyses of tornado-borne missile velocities adopted for Revision 1 to RG 1.76. However, the assumed hurricane wind field differs from the assumed tornado wind field in that the hurricane wind field does not change spatially during the missile’s flight time but does vary with height above the ground. Because the size of the hurricane zone with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum (3-second gust) wind speed.

Accordingly, the applicant is being requested to add hurricane wind speed and hurricane missile spectra to its list of site parameter values in Tier 1 and Tier 2 of the FSAR and show in Chapter

3 of Tier 2 of the FSAR how SSCs important to safety are protected from the combined effects of hurricane winds and missiles.

Response to Question 02-3:

The highest design basis hurricane speed is shown to be 290 mph in RG 1.221; however, only limited territory along the East Coast and the Mexican Gulf fall into these regions. The highest hurricane wind speed in the main land read from the RG 1.221 is 230 mph. A hurricane design wind speed of 230 mph is therefore selected to match the current tornado design wind speed. The hurricane design wind speed of 230 mph will be added to the site parameters to U.S. EPR FSAR Tier 1, Table 5.0-1. The U.S. EPR FSAR Tier 1, Section 2.0 “System Based Design Description of ITAAC” will also be revised to include hurricane.

RG 1.221 presents a design basis hurricane missile spectrum for nuclear power plants which is the same as the design basis tornado missile spectrum presented in Revision 1 of RG 1.76. This spectrum includes (1) a massive high kinetic-energy missile that deforms on impact (an automobile), (2) a rigid missile that tests penetration resistance (a pipe), and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers (a solid steel sphere). At a hurricane design wind speed of 230 mph, the respective design basis horizontal hurricane missile velocities (ft/s) are 222, 176, and 155. The design basis vertical missile velocity for hurricane missiles is 85 ft/s. The design basis hurricane wind and hurricane missile spectrum will be added to the site basic parameters in U.S. EPR FSAR Tier 2, Table 2.1-1.

Existing procedures and requirements for protection of structures, systems, and components (SSCs) important to safety subjected to combined effects of tornado winds and missiles are also applicable to combined effects of hurricane winds and missiles.

Tornado effects considered in the design of safety related SSCs include combinations of tornado wind effects, atmospheric pressure change effects, and tornado-generated missile impact effects. The same approach for combining the effects of tornado winds and missiles is used to combine the effects of hurricane winds and missiles, except that the load from the hurricane atmospheric pressure change is negligible. As a result, the maximum enveloping combined extreme wind loading due to tornado or hurricane is used in performing load combination calculations. U.S. EPR FSAR Tier 2, Sections 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5 will be revised accordingly.

Hurricane wind velocity is converted into effective pressure that is applied to the surfaces of U.S. EPR Seismic Category I and II SSCs important to safety in the same way in which severe wind pressure loads are determined. The Static Structural Analyses have been updated to incorporate the hurricane wind effects. U.S. EPR FSAR Tier 2 Sections 3.3, 3.3.1, and 3.3.2 will be updated to reflect that hurricane and tornado winds are considered extreme winds. Loads considered for the design of critical sections will be provided in the Response to RAI 155, Question 3.8.4-6.

Since the hurricane missile spectrum is the same as the tornado missile spectrum, U.S. EPR FSAR Tier 2, Section 3.5.1.4 is also applicable to hurricane will be revised accordingly. The same design approach and methodology described in U.S. EPR FSAR Tier 2, Section 3.5.3 “Barrier Design Procedures” are also used in the design evaluation of safety related structures, with the exception that the horizontal hurricane missile velocities are higher than the horizontal tornado missile velocities and the vertical hurricane missile velocities are constant.

ITAAC for hurricane and tornado loading of the Nuclear Auxiliary Building are addressed in the Response to RAI 592.

FSAR Impact:

U. S. EPR FSAR Tier 1, Sections 2.1.1, 2.1.2, 2.1.5, and Tables 2.1.1-8, 2.1.1-10, 2.1.1-11, 2.1.2-3, 2.1.5-3 and 5.0-1 will be revised as described in the response and indicated in the enclosed markup.

U.S. EPR FSAR Tier 2, Sections 1.2.1, 1.2.3, 2.3, 3.1.1, 3.3, 3.3.2, 3.5.1, 3.5.2, 3.5.3, 3.8.1, 3.8.2, 3.8.3, 3.8.4, 3.8.5, 3.9.3.1, 4.6.1, 6.2.1, 7.1.3, 8.2.2, 8.3.1, 9.2.5, 9.4.11, 9.5.4, 10.3.3, 11.4.1, 16, 19.1.5, and Tables 1.8-1, 1.8-2, 1.9-2, 2.1-1, 3.5-1, 3.5-2, 3.9.3-2, and 3.9.3-4 will be revised as described in the response and indicated in the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

The containment is separated into two regions referred to as the two room containment. Separation is maintained by rupture foils, convection foils, and doors, which open to transform the two room containment into a one-room containment. Rupture foils and convection foils are part of the combustible gas control system (CGCS) and are addressed in Section 2.3.1. Doors used as separation barriers are designed to open or provide an opening to relieve pressure in support of the transformation, making them a "pressure relief device" for their respective compartments. The doors provide this pressure relief function by swinging open or by use of a pressure balance aperture (blowout panel) in the door.

2.0 Mechanical Design Features

2.1 Six rib support structures, provided at the bottom of the reactor cavity, as shown on Figure 2.1.1-9—Reactor Building Elevation Section C-C, limit lower reactor pressure vessel head deformation due to thermal expansion and creep during severe accident mitigation.

2.2 As shown on Figure 2.1.1-4—Reactor Building Plan Elevation -8 ft., a flooding barrier is provided to prevent ingress of water into the core melt spreading area. Penetrations within the core melt water ingression barrier are protected by watertight seals. Doors within the core melt water ingression barrier are watertight doors.

2.3 Core melt cannot relocate to the upper containment due to the existence of concrete barriers as shown on Figure 2.1.1-9.

2.4 The RB structures are Seismic Category I and are will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions:

- Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads).
- Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, and missile impact loads).
- External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).

2.5 The RCB, including the liner plate and penetration assemblies, maintains its pressure boundary integrity at the design pressure.

2.6 The RCB is post-tensioned, pre-stressed concrete structure.

2.7 ~~Internal h~~Hazard protection barriers as shown on Figure 2.1.1-20—Reactor Building Internal Hazards Separation Barrier through Figure 2.1.1-44—Fuel Building Internal Hazards Separation Barrier - Plan Elevation +64 ft separate the RBA from the SBs and the FB, and the RBA from the RCB so that the impact of internal hazards, including fire, flood, high-~~line~~ energy line break and missile impact, is contained within the RBA.

2.1.1.2 Safeguard Buildings

Design Description

1.0 System Description

The SBs are reinforced concrete, Seismic Category I, safety-related structures located around the perimeter of the RSB. The SBs are arranged to accommodate four safeguard divisions. SB 4 and 1 are located adjacent to the RSB as shown on Figure 2.1.1-2. SBs 2 and 3 are contained in a single structure separated by a common wall and are located adjacent to the RSB as shown on Figure 2.1.1-2. As shown on Figure 2.1.1-15 and Figure 2.1.1-17, SBs 2 and 3 are decoupled from the external hazards barrier by a gap between the SBs external walls and their uppermost ceilings. The SBs and the RSB share the reinforced concrete cylindrical shell from the basemat to elevation 0 feet, 0 inches; above this elevation the structures are physically separated by a seismic gap.

The SBs 2 and 3 structure has overall dimensions of approximately 92 feet out from the RSB wall by 180 feet long by 140 feet high. The SB 1 structure has overall dimensions of approximately 87 feet out from the RSB wall by 100 feet long by 115 feet high. The SB 4 structure has dimensions of approximately 87 feet out from the RSB wall by 100 feet long by 150 feet high.

The primary function of the SBs is to provide physical separation between redundant divisions of safeguard equipment. The main control room (MCR) and the technical support center (TSC) are located within SBs 2 and 3 as shown on Figure 2.1.1-16. The remote shutdown station (RSS), which is separate from the MCR, is located within SB 3 as shown on Figure 2.1.1-15. Also located in the SBs 1 and 4 are the reinforced concrete main steam and feedwater valve rooms. ~~Stair towers are provided between the different SBs and the SBs and FB.~~

2.0 Mechanical Design Features

2.1 The SB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions:

- Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads).
- Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, and missile impact loads).
- External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).

2.1.1.3 Fuel Building

Design Description

1.0 System Description

The FB is a reinforced concrete, Seismic Category I, safety-related structure, which includes a steel Seismic Category I, safety-related vent stack. ~~It~~ The FB extends approximately 58 feet out from the RSB wall and is approximately 160 feet long by 140 feet high. The FB is located adjacent to the RSB at 180 degrees as shown on Figure 2.1.1-2. As shown on Figure 2.1.1-11 and Figure 2.1.1-12, a portion of the FB is decoupled from the external hazards barrier by a gap between the FB external wall and its uppermost ceiling. The FB and the RSB share the reinforced concrete cylindrical shell from the basemat to elevation 0 feet 0 inches; above this elevation the structures are physically separated by a seismic gap. The primary function of the FB is to house new and spent fuel and to provide radiation protection during normal operation by shielding areas of higher radiation from areas of lower radiation. The ~~Seismic Category I FB structure includes the vent stack. The FB supports the~~ vent stack~~,~~ is a steel structure approximately 12 feet, 6 inches in diameter by 100 feet high located on the roof of the Fuel Building as shown on Figure 2.1.1-2.~~top of the stair tower between the FB and SB 4. Stair towers are provided between the different SBs and the FB. These stair towers provide personnel access among the various elevations of the NI and tie together the buildings around the periphery of the RSB.~~

2.0 Mechanical Design Features

2.1 The FB structure, including the vent stack, is Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions:

- Normal plant operation (including dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads).
- Internal events (including internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, and missile impact loads).
- External events (including wind, extreme winds, rain, snow, flood, ~~tornado,~~ ~~tornado~~extreme winds-generated missiles and earthquake).

2.2 ~~Internal h~~Hazard protection barriers as shown on Figure 2.1.1-20—Reactor Building Internal Hazards Separation Barrier and Figure 2.1.1-38—Fuel Building Internal Hazards Separation Barrier - Plan Elevations -31 ft. Through -11 ft. through Figure 2.1.1-44—Fuel Building Internal Hazards Separation Barrier - Plan Elevations +79 ft. Through +90 ft. separate independent divisions within the FB and the FB from other NI structures so that the impact of internal hazards, including fire, flood, high-~~line~~ energy line break and missile impact is contained within the independent divisions within the FB of hazard origination.

Table 2.1.1-8—Reactor Building ITAAC
Sheet 2 of 10

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.4	The RB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions: • Normal plant operation (~~including~~ e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).	An inspection and analysis will be performed to verify the as-built RB structures will withstand design basis loads.	A report concludes that the RB structures will withstand the design basis loads, as specified below, without loss of structural integrity and safety-related functions: • Normal plant operation (e.g.,~~including~~ dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (e.g.,~~including~~ internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (e.g.,~~including~~ wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).

Table 2.1.1-10—Safeguard Buildings ITAAC
Sheet 1 of 2

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.1	The SB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions. • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (~~including~~ e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).	An inspection and analysis will be performed to verify the as-built SB structures will withstand design basis loads.	A report concludes that the SB structures will withstand the design basis loads, as specified below, without loss of structural integrity or safety-related functions • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (~~including~~ e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~ e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake).
2.2	~~Internal h~~Hazard protection barriers as shown on Figure 2.1.1-20 through Figure 2.1.1-44~~37~~ separate each SB from the other SBs and the FB so that the impact of internal hazards, including fire, flood, high-energy line break and missile impact is contained within the SB of hazard origination.	An inspection will be performed to verify the configuration of as-built ~~internal~~ hazard protection barriers that separate each SB from the other SBs and the FB.	The configuration of ~~internal~~ hazard protection barriers that separate each SB from the other SBs and the FB is ~~as~~ shown on Figure 2.1.1-20 through Figure 2.1.1-44~~37~~.

Table 2.1.1-11—Fuel Building ITAAC
Sheet 1 of 2

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.1	The FB structure, including the vent stack, is Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions: • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (~~including~~ e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~ e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake.	An inspection and analysis will be performed to verify the as-built FB structure~~s~~, including the vent stack, will withstand design basis loads.	A report concludes that the FB structure~~s~~, including the vent stack, will withstand the design basis loads, as specified below, without loss of structural integrity or safety-related functions: • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, equipment loads, hydrostatic, hydrodynamic, and temperature loads). • Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads, including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~ e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles and earthquake.

2.1.2 Emergency Power Generating Buildings

Design Description

1.0 System Description

The Emergency Power Generating Buildings (EPGB) are safety-related, Seismic Category I, reinforced concrete structures supported by a reinforced concrete basemat. There are two essentially identical EPGBs (EPGB 1/2 and EPGB 3/4) located adjacent to the Nuclear Island (NI). To address aircraft and explosion pressure wave hazards, these structures are physically separated by the NI complex as illustrated on Figure 2.1.2–1. Information in tables and figures in this section is for information only with the exception of the specific features listed in the ITAAC for verification.

Each structure houses two diesel generators, two fuel oil tanks, two control rooms, heating ventilation and air conditioning (HVAC) equipment, electrical equipment, and miscellaneous equipment associated with the operation of each generator. The two diesel generators are separated by a reinforced concrete wall to protect against internal hazards. The two fuel oil tanks are separated from the diesel generators by a reinforced concrete wall to protect against internal hazards.

The EPGBs are Seismic Category I structures, which are capable of performing their safety-related function during and following a safe shutdown earthquake (SSE). These structures are designed for external hazards including rain and snow loads, flooding, wind loads, extreme wind~~tornado~~ loads, missile impact loads, SSE loads, and site-proximity hazards. The buildings are also designed for structure and component dead loads, live loads, pipe reactions, and thermal effects. There are no internally generated missile impact loads applicable to the design of these buildings.

Each EPGB provides the following safety-related functions:

- Supports the emergency diesel generators and associated mechanical, electrical, and instrumentation and control equipment required to function during and after a design basis event.
- Provides protection for safety-related equipment against external hazards.
- Provides separation between the main diesel generators and fuel oil tanks.
- Each EPGB structure is approximately 95 feet by 178 feet by 68 feet high.

2.0 Arrangement

2.1 The basic configuration of the EPGBs is as shown on Figure 2.1.2-1—U.S. EPR Building Layout Showing EPGB Locations.

3.0 Mechanical Design Features

3.1 Separation is provided between the EPGBs and the NI common basemat structures as shown on Figure 2.1.2-1 to preclude interaction between the EPGBs and NI common basemat structures.

3.2 The EPGBs site grade level is located between 12 inches and 18 inches below finish floor elevation at ground entrances.

3.3 ~~Internal h~~Hazard protection barriers, as shown on Figure 2.1.2-4—Emergency Diesel Generator Building Internal Hazards Separation Barrier, separate internal rooms within each EPGB and EPGB 1 from EPGB 2 and EPGB 3 from EPGB 4 ~~each EPGB from the other EPGBs as shown on Figure 2.1.1-20—Reactor Building Internal Hazards Separation Barrier through Figure 2.1.1-37—Safeguard Building 4 Internal Hazards Separation Barrier—Plan Elevation +81 ft.~~ so that the impact of internal hazards, including fire, flood, high-energy line break and missile impact is contained within respective room of the EPGB of hazard origination.

3.4 The EPGB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions:

- Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads).
- Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads—including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads).
- External events (~~including~~e.g., wind, extreme winds rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles, and earthquake).

3.5 Deleted.

3.6 The EPGB structures have key dimensions and tolerances specified in Table 2.1.2-1—Key Dimensions of Emergency Power Generating Building Structure and Table 2.1.2-2—Key Dimensions of Emergency Power Generating Building Foundation Footprint.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.1.2–3 lists the EPGB ITAAC.

Table 2.1.2-3—Emergency Power Generating Building ITAAC
Sheet 2 of 2

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
3.4	The EPGB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions: • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads). • Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads – including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles, and earthquake).	An inspection and analysis will be performed to verify the as-built EPGB structures will withstand design basis loads.	A report concludes that the EPGB structures will withstand the design basis loads, as specified below, without loss of structural integrity or safety-related functions: • Normal plant operation (~~including~~e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads). • Internal events (~~including~~e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reactions, and pipe break loads – including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). • External events (~~including~~e.g., wind, extreme winds, rain, snow, flood, ~~tornado, tornado~~extreme winds-generated missiles, and earthquake).
3.5	Deleted.	Deleted.	Deleted.
3.6	The EPGB structures have key dimensions and tolerances specified in Table 2.1.2-1 and Table 2.1.2-2.	An inspection will be performed to verify key dimensions and tolerances of the as-built EPGB structures.	The EPGB structures conform to the key dimensions and tolerances specified in Table 2.1.2-1 and Table 2.1.2-2.

2.1.5 Essential Service Water Building

Design Description

1.0 System Description

Each of the four Essential Service Water Buildings (ESWB) is an independent, safety related, Seismic Category I, reinforced concrete structure. Each ESWB houses an Essential Service Water Cooling Tower structure (ESWCT) and an Essential Service Water Pump Building (ESWPB). The ESWCT houses two cooling towers and a water storage basin. The ESWPB houses pumps and electrical equipment. A total of four ESWBs are located in pairs on each side of the Nuclear Island (NI) complex. The pairs of buildings are separated to protect them from being simultaneously affected by external events such as aircraft hazards and explosion pressure waves. As shown on Figure 2.1.5-1, one pair is located adjacent to the Turbine Building and the other pair is located adjacent to the Fuel Building (FB).

Each ESWB is embedded 21 ft below grade and is approximately 164 ft by 108 ft wide by 118 ft high (i.e., from the bottom of the basemat to the top of the building at elevation 96 ft 0 in.). The ESWBs are Seismic Category I structures, which are capable of performing their safety function during and following a safe shutdown earthquake (SSE). The buildings are designed for external hazards including rain and snow, flooding, wind loads, extreme winds loads, missile impact loads, SSE loads, and site proximity hazards. The buildings are also designed for structure and component dead loads, live loads, pipe reactions, and thermal effects.

The function of the ESWBs is to house equipment and cooling water associated with the Essential Service Water System.

2.0 Arrangement

2.1 The basic configuration of the ESWBs is as shown on Figure 2.1.5-1—U.S. EPR Building Layout Showing ESWB Locations.

3.0 Mechanical Design Features

3.1 Separation is provided between the two pairs of ESWBs and the NI common basemat structures as shown on Figure 2.1.5-1 to preclude interaction between the ESWBs and NI common basemat structures.

3.2 The ESWBs have ~~tornado~~extreme wind-generated missile protection shields provided for the safety-related fans and pumps as shown on Figure 2.1.5-2—Essential Service Water Building Plan Elevation +14 ft., Figure 2.1.5-3—Essential Service Water Building Plan Elevation +63 ft., Figure 2.1.5-4—ESWB Elevation Section A-A, and Figure 2.1.5-5—ESWB Elevation Section B-B.

3.3 The ESWBs site grade level is located within +/- 3 inches of the building +0 ft elevation.

3.4 Internal hazard protection barriers separate each ESWB from the other ESWBs so that the impact of internal hazards, including fire, flood, high-energy line break and missile impact, is contained within the ESWB of hazard origination.

3.5 The ESWB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions.

- Normal plant operation (e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads).
- Internal events (e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reaction, and pipe break loads—including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads).
- External events (e.g., wind, extreme winds, rain, snow, flood, extreme winds-generated missiles, and earthquake).

3.6 ESWB structural walls or floors having exterior penetrations located below grade elevation are protected against external flooding by watertight seals.

3.7 The ESWB structures have key dimensions and tolerances specified in Tables 2.1.5-1—Key Dimensions of Essential Service Water Building Structure and 2.1.5-2—Key Dimensions of Essential Service Water Building Foundation Footprint.

Inspections, Tests, Analyses, and Acceptance Criteria

Table 2.1.5-3 lists ESWB ITAAC.

Table 2.1.5-3—Essential Service Water Building ITAAC
Sheet 1 of 3

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
2.1	The basic configuration of the ESWBs is as shown on Figure 2.1.5-1.	An inspection of the basic configuration of the as-built ESWBs will be performed.	The basic configuration of the ESWBs is as shown on Figure 2.1.5-1.
3.1	Separation is provided between the two pairs of ESWBs and the NI common basemat structures as shown on Figure 2.1.5-1 to preclude interaction between the ESWBs and NI common basemat structures.	An inspection will be performed to verify the as-built physical separation distance between the ESWBs and the NI common basemat structures.	The two pairs of ESWBs are separated from the NI common basemat structures as shown on Figure 2.1.5-1. A separation distance of at least 20 ft exists between the two pairs of ESWBs and NI common basemat structures.
3.2	The ESWBs have extreme wind-generated missile protection shields provided for the safety-related fans and pumps as shown on Figure 2.1.5-2, Figure 2.1.5-3, Figure 2.1.5-4, and Figure 2.1.5-5.	An inspection and analysis will be performed to verify the as-built ESWB ~~tornado~~extreme wind-generated missile protection shields provided for the safety-related fans and pumps will withstand design basis extreme wind loads without loss of structural integrity or safety-related functions.	A report concludes that the ESWB ~~tornado~~extreme wind-generated missile protection shields provided for the safety-related fans and pumps as shown on Figure 2.1.5-2, Figure 2.1.5-3, Figure 2.1.5-4, and Figure 2.1.5-5 will withstand the design basis extreme wind loads without loss of structural integrity or safety-related functions.
3.3	The ESWBs site grade level is located within +/- 3 inches of the building +0 ft elevation.	An inspection will be performed to verify the as-built ESWBs site grade level at building +0 ft elevation.	The ESWB site grade level is located within +/- 3 inches of the building +0 ft elevation.

Table 2.1.5-3—Essential Service Water Building ITAAC
Sheet 3 of 3

	Commitment Wording	Inspections, Tests, Analyses	Acceptance Criteria
3.5	The ESWB structures are Seismic Category I and will withstand design basis loads, as specified below, without loss of structural integrity and safety-related functions: ● Normal plant operation (e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads). ● Internal events (e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reaction, and pipe break loads – including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). ● External events (e.g., wind, extreme winds, rain, snow, flood, extreme winds-generated missiles, and earthquake).	An inspection and analysis of the as-built ESWB structures for the design basis loads will be performed.	A report concludes that the ESWB structures will withstand the design basis loads as specified below without loss of structural integrity or safety-related functions: ● Normal plant operation (e.g., dead loads, live loads, lateral earth pressure loads, hydrostatic loads, hydrodynamic loads, and temperature loads). ● Internal events (e.g., internal flood loads, accident pressure loads, accident thermal loads, accident pipe reaction, and pipe break loads – including reaction loads, jet impingement loads, cubicle pressurization loads, and missile impact loads). ● External events (e.g., wind, extreme winds, rain, snow, flood, extreme winds-generated missiles, and earthquake).
3.6	ESWB structural walls or floors having exterior penetrations located below grade elevation are protected against external flooding by watertight seals.	An inspection will be performed to verify as-built ESWB structural walls or floors having exterior penetrations located below grade elevation are protected against external flooding by watertight seals.	Watertight seals exist for exterior penetrations of ESWB structural walls and floors located below grade elevation.
3.7	The ESWB structures have key dimensions and tolerances specified in Tables 2.1.5-1 and 2.1.5-2.	An inspection will be performed to verify key dimensions and tolerances of the as-built ESWB structures.	The ESWB structures conform to the key dimensions and tolerances specified in Tables 2.1.5-1 and 2.1.5-2.

Next File

Table 5.0-1—Site Parameters for the U.S. EPR Design
Sheet 1 of 3

Precipitation	
Parameter	**Value(s)**
Rainfall rate	≤19.4 in/hr
Sum of normal winter precipitation event and extreme frozen winter precipitation event ground load.	≤143 psf(1)
Seismology	
Parameter	**Value(s)**
Horizontal SSE Acceleration	0.3g PGA for EUR and 0.21g PGA for HF (CSDRS shapes – See Figure 5.0-1)
Vertical SSE Acceleration	0.3g PGA for EUR and 0.18g PGAfor HF (CSDRS shapes – See Figure 5.0-1)
Fault Displacement Potential	No fault displacement is considered for safety-related SSC in U.S. EPR design certification.
Flood Level	
Parameter	**Value(s)**
Maximum flood or tsunami	Maximum flood or tsunami level is no more than 1 ft below grade.
Temperature	
Parameter	**Value(s)**
Design ambient temperature	The 0% exceedance maximum ambient temperature is 115°F Dry Bulb and 80°F Wet Bulb (mean coincident).(2) The 0% exceedance minimum ambient temperature is -40°F.(2) The 1% exceedance (seasonal basis)(3) maximum ambient temperature is 100°F Dry Bulb and 77°F Wet Bulb (mean coincident). The 1% exceedance (seasonal basis) (3) minimum ambient temperature is -10°F.
Wind	
Parameter	**Value(s)**
Maximum Speed (Other than Tornado and Hurricane)	The normal maximum wind speed is 145 mph.

Table 5.0-1—Site Parameters for the U.S. EPR Design
Sheet 2 of 3

Tornado	
Parameter	**Value(s)**
Tornado (maximum speed, pressure drop, radius of maximum rotational speed, rate of pressure drop, missile spectra)	Maximum tornado wind speed of 230 mph. Maximum rotational speed of 184 mph. Maximum tornado pressure drop of 1.2 pounds per square inch at 0.5 psi per second. Radius of maximum rotational speed is 150 ft.
Hurricane	**Value(s)**
Hurricane (maximum speed)	Maximum hurricane wind speed of 230 mph.
Soil	
Parameter	**Value(s)**
Soil properties: Minimum angle of internal friction (in situ and backfill)	26.6 degrees(4)
Minimum shear wave velocity	Minimum shear wave velocity (low strain best estimate average value at bottom of basemat) of 1000 feet per second.
Minimum static bearing capacity	Maximum static bearing demand is 23,100~~24~~,~~000~~ lbs/ft^2 at the bottom of the Seismic Category I structure basemats. The ultimate static bearing capacity divided by 3.0 is greater than or equal to the maximum static bearing demand.
Minimum dynamic bearing capacity	The maximum dynamic bearing demand (combination of safe shutdown earthquake and static loads) at the corner of any Seismic Category I Structure basemat is: • 38,000 lbs/ft^2 (for soft soil)(5) • 48,000 lbs/ft^2 (for medium soil)(5) • 60,000 lbs/ft^2 (for hard soil)(5) For a site with shear wave velocity between soft and medium soil conditions or between medium and hard soil conditions, the maximum dynamic bearing demand is the larger of the two values. For sites not meeting the soil property requirements, a site-specific analysis is required.~~Maximum dynamic bearing demand is 35,000 lbs/ft^2 at the toe of the Seismic Category I structure basemats.~~ The ultimate dynamic bearing capacity divided by 2.0 is greater than or equal to the maximum dynamic bearing demand.
Liquefaction potential	No potential for liquefaction under footprint of Seismic Category I structures from site-specific SSE.
Maximum ground water level	Maximum ground water level is 3.3 ft below grade.

probabilistic approach to define these events and assess the specific measures available for their management. Consistent with international and U.S. probabilistic safety objectives, the CDF is less than 10^{-5}/reactor-year, including all events and all reactor states. Additionally, the overall mean LRF of radioactive materials to the environment from a core damage event is less than 10^{-6}/reactor-year.

Innovative features result in the low probability of energetic scenarios that could lead to early containment failure. Design provisions for the reduction of the residual risk, core melt mitigation, and the prevention of large releases are as follows:

- Prevention of high pressure core melt by high reliability of decay heat removal systems, complemented by primary system overpressure protection (OPP).
- Primary system discharge into the containment in the event of a total loss of secondary side cooling.
- Features for corium spreading and cooling.
- Prevention of hydrogen detonation by reducing the hydrogen concentration in the containment at an early stage with catalytic hydrogen recombiners.
- Control of the containment pressure increase by a dedicated severe accident heat removal system (SAHRS) consisting of a spray system with recirculation through the cooling structure of the melt stabilization system.
- Collection of leaks and prevention of bypass of the containment.

External hazards (e.g., explosion pressure wave (EPW), seismic events, tornado-generated and hurricane-generated missiles, wind, fire) and aircraft hazards have been considered in the design of Safeguard Buildings and the hardening of the Shield Building.

1.2.2 Site Description

The U.S. EPR is a standard plant design that can be built on a site with parameters as described in Section 1.3 and in Table 1.3-1—U.S. EPR Comparison with Similar Facilities. These site parameters relate to the seismology, hydrology, meteorology, geology, heat sink, and other site-related aspects that form the basis for the U.S. EPR design. Figure 1.2-1—3-Dimensional Conceptual Configuration of U.S. EPR Buildings, Figure 1.2-2—U.S. EPR Cutaway, and Figure 1.2-3—Plant Configuration, show the layout and configuration of a generic U.S. EPR. General Arrangement drawings of the following structures are identified below:

Reactor Building, Safeguards Buildings, Fuel Buildings, Emergency Power Generating Buildings, Essential Service Water Building Plan – Section 3.8.

Nuclear Auxiliary Building – Figures 1.2-4 through 1.2-17.

separate reinforced concrete buildings; the two EDGs in each building are in separate locations within the building. In addition to the four safety-related diesels, two independent non-safety-related station blackout (SBO) diesel generators are available to power essential equipment during an SBO event (i.e., a LOOP with coincident failure of all four EDGs).

Additional safety systems and features are located in and around the RCS and the Reactor Building. Water storage for safety injection is provided by the in-containment refueling water storage tank (IRWST). Also located inside containment, below the reactor pressure vessel (RPV), is a dedicated spreading area for molten core material following a postulated worst-case severe accident. Furthermore, the fuel pool is adjacent to the Reactor Building in a dedicated building to simplify access for fuel handling during plant operation and handling of fuel casks. Two divisions of redundant, safety-related cooling systems provide fuel pool cooling.

The ultimate heat sink (UHS) consists of four division-related and independent mechanical draft cooling towers connected to the essential service water system (ESWS) through intake and discharge paths, with water storage basins associated with each cooling tower.

1.2.3.1.2 Buildings and Arrangement

The Nuclear Island (NI) includes the Reactor Building, Safeguard Buildings, and the Fuel Building, all of which are located on a common basemat. The Nuclear Auxiliary Building, two Emergency Power Generating Buildings, the Radioactive Waste Processing Building, and the UHS structures are located on individual basemats. Additionally, an Access Building is provided, which includes functions such as the health physics area, access control, and personnel facilities (showers, locker rooms). The Access Building is further described in Section 3.7.2. Figure 1.2-1 and Figure 1.2-3 show the general layout of the major U.S. EPR Buildings. Note that any building dimensions in these figures are for information only.

Both the structural design and physical arrangement of the U.S. EPR buildings provide protection from both external and internal hazards. Physical separation protects each safety system division against the propagation of internal hazards (e.g., fire, high-energy line break, flooding) from one division to another. Safety-related buildings are also designed to withstand the effects of the safe shutdown earthquake (SSE), a hurricane, and a tornado.

Protection of the U.S. EPR against external hazards (including aircraft impact) is provided by the following design features:

- A hardened concrete shell protects Safeguard Buildings 2 and 3, the Reactor Building, and the Fuel Building.

Table 1.8-1—Summary of U.S. EPR Plant Interfaces with Remainder of Plant
Sheet 1 of 2

Item No.	Interface	Interface Type	Section
1-1	Switchgear Building	U.S. EPR Interface	1.2, 8.3, 8.4
1-2	Access Building	U.S. EPR Interface	1.2, 3.7.2
1-3	Turbine Building	U.S. EPR Interface	1.2, 3.7.2
1-4	Fire Protection Storage Tanks and Building	U.S. EPR Interface	1.2, 3.7.2
2-1	Envelope of U.S. EPR site related design	Site Parameter	2.0, Table 2.1-1
2-2	Consequences of potential hazards from nearby industrial, transportation and military facilities	Site Parameter	2.2
2-3	Site-specific χ/Q values based on site-specific meteorological data at the exclusion area boundary (EAB), low population zone (LPZ), and control room	Site Parameter	2.3
2-4	Site-specific seismic characteristics	Site Parameter	2.5, 3.7
2-5	Soil conditions and profiles	Site Parameter	2.5, 3.7
2-6	Bearing pressure of soil beneath the nuclear island basemat	Site Parameter	2.5
2-7	Foundation settlements	Site Parameter	2.5
3-1	Missiles generated from nearby facilities	Site Parameter	3.5
3-2	Missiles generated by ~~tornadoes or~~ extreme winds	Site Parameter	3.5
3-3	Aircraft hazards	Site Parameter	3.5
3-4	Site-specific loads that lie within the standard plant design envelope for Seismic Category I structures	Site Parameter	3.8
3-5	Buried conduit and duct banks, and pipe and pipe ducts	U.S. EPR Interface	3.8
8-1	Off-site ac power transmission system connections to the switchyard and the connection to the plant power distribution system	U.S. EPR Interface	8.2
8-2	On-site ac power transmission system connections to the switchyard and the connection to the plant power distribution system	U.S. EPR Interface	8.3
8-3	Auxiliary power and generator transformer areas	U.S. EPR Interface	8.2
8-4	Lightning protection and grounding system grid	U.S. EPR Interface	8.3.1
8-5	Design details for electrical distribution for circulating water system components outside the Turbine Building.	U.S. EPR Interface	8.3

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 8 of 41

Item No.	Description	Section
3.3-1	A COL applicant that references the U.S. EPR design certification will determine site-specific wind, hurricane, and tornado characteristics and compare these to the standard plant criteria. If the site-specific wind, hurricane, and tornado characteristics are not bounded by the site parameters, postulated for the certified design, then the COL applicant will evaluate the design for site-specific wind, hurricane, and tornado events and demonstrate that these loadings will not adversely affect the ability of safety-related structures to perform their safety functions during or after such events.	3.3
3.3-2	A COL applicant that references the U.S. EPR design certification will demonstrate that failure of site-specific structures or components not included in the U.S. EPR standard plant design, and not designed for wind loads, will not affect the ability of other structures to perform their intended safety functions.	3.3.1
3.3-3	A COL applicant that references the U.S. EPR design certification will demonstrate that failure of site-specific structures or components not included in the U.S. EPR standard plant design, and not designed for hurricane and tornado loads, will not affect the ability of other structures to perform their intended safety functions.	3.3.2
3.4-1	A COL applicant that references the U.S. EPR design certification will confirm the potential site specific external flooding events are bounded by the U.S. EPR design basis flood values or otherwise demonstrate that the design is acceptable.	3.4.3.2
3.4-2	A COL applicant that references the U.S. EPR design certification will perform a flooding analysis for the ultimate heat sink makeup water intake structure based on the site-specific design of the structures and the flood protection concepts provided herein.	3.4.3.10
3.4-3	A COL applicant that references the U.S. EPR design certification will define the need for a site-specific permanent dewatering system.	3.4.3.11
3.4-4	Deleted. ~~A COL applicant that references the U.S. EPR design certification will perform internal flooding analyses prior to fuel load for the Safeguard Buildings and Fuel Building to demonstrate that the impact of internal flooding is contained within the Safeguard Building or Fuel Building division of origin.~~	Deleted~~3.4.1~~
3.4-5	Deleted.~~A COL applicant that references the U.S. EPR design certification will perform an internal flooding analysis prior to fuel load for the Reactor Building and Reactor Building Annulus to demonstrate that the essential equipment required for safe shutdown is located above the internal flood level.~~	Deleted~~3.4.1~~

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 9 of 41

Item No.	Description	Section
3.4-6	A COL applicant that references the U.S. EPR design certification will include in its maintenance program appropriate watertight door preventive maintenance in accordance with manufacturer recommendations so that each Safeguards Building and Fuel Building watertight door above elevation +0 feet remains capable of performing its intended function.	3.4.1
3.4-7	A COL applicant that references the U.S. EPR design certification will design the watertight seal between the Access Building and the adjacent Category I access path to the Reactor Building Tendon Gallery. Watertight seal design will account for hydrostatic loads, lateral earth pressure loads, and other applicable loads.	3.4.2
3.5-1	A COL applicant that references the U.S. EPR design certification will describe essential elements of a program~~controls~~ to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be removed from containment prior to operation, moved to a location where it is not a potential hazard to safety-related SSC, or seismically restrained to prevent it from becoming a missile.	3.5.1.2.3
3.5-2	A COL applicant that references the U.S. EPR design certification will confirm the evaluation of the probability of turbine missile generation for the selected turbine generator, P1, is less than 1 x 10^{-5}~~^{4}~~ for turbine-generators unfavorably oriented. ~~with respect to containment.~~	3.5.1.3
3.5-3	A COL applicant that references the U.S. EPR design certification will assess the effect of potential turbine missiles from turbine generators within other nearby or co-located facilities.	3.5.1.3
3.5-4	A COL applicant that references the U.S. EPR design certification will evaluate the potential for other missiles generated by natural phenomena, such as hurricane~~s~~ and tornado~~extreme~~ winds, and their potential impact on the missile protection design features of the U.S. EPR.	3.5.1.4
3.5-5	A COL applicant that references the U.S. EPR design certification will evaluate the potential for site proximity explosions and missiles generated by these explosions for their potential impact on missile protection design features.	3.5.1.5
3.5-6	A COL applicant that references the U.S. EPR design certification will evaluate site-specific aircraft hazards and their potential impact on plant SSC.	3.5.1.6

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 15 of 41

Item No.	Description	Section
3.9-5	As noted in ANP-10264NP-A, should a COL applicant that references the U.S. EPR design certification find it necessary to route Class 1, 2, and 3 piping not included in the U.S. EPR design certification so that it is exposed to wind, hurricane, and tornadoes, the design must withstand the plant design-basis loads for this event.	3.9.3.1.1
3.9-6	A COL applicant that references the US EPR design certification will identify any additional site-specific valves in Table 3.9.6-2 to be included within the scope of the IST program.	3.9.6.3
3.9-7	A COL applicant that references the U.S. EPR design certification will submit the preservice testing (PST) program and IST program for pumps, valves, and snubbers as required by 10 CFR 50.55a.	3.9.6
3.9-8	A COL applicant that references the US EPR design certification will identify any additional site-specific pumps in Table 3.9.6-1 to be included within the scope of the IST program.	3.9.6.2
3.9-9	COL applicant that references the U.S. EPR design certification will either use a piping analysis program based on the computer codes described in Section 3.9.1 and Appendix 3C or will implement a U.S. EPR benchmark program using models specifically selected for the U.S. EPR.	3.9.1.2
3.9-10	Pipe stress and support analysis will be performed by a COL applicant that references the U.S. EPR design certification.	3.9.1.2
3.9-11	Deleted.~~A COL applicant that references the U.S. EPR design certification will provide a summary of the maximum total stress, deformation (where applicable), and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components. For those values that differ from the allowable limits by less than 10 percent, the COL applicant will provide the contribution of each of the loading categories (e.g., seismic, pipe rupture, dead weight, pressure, and thermal) to the total stress for each maximum stress value identified in this range. The COL applicant will also provide the maximum total stress and deformation values for each operating condition for Class 2 & 3 components required for safe shutdown of the reactor, or mitigation of consequences of a postulated piping failure without offsite power. Identification of those values that differ from the allowable limits by less than 10 percent will also be provided.~~	Deleted~~3.9.3.1~~

Table 1.9-2—U.S. EPR Conformance with Regulatory Guides
Sheet 17 of 19

RG / Rev	Description	U.S. EPR Assessment	FSAR Section(s)
1.205, 05/2006	Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants	N/A-COL	N/A
1.206, 06/2007	Combined License Applications for Nuclear Power Plants (LWR Edition)	Y	1.1.6.1
1.207, 03/2007	Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors	Y	3.12.5
1.208, 03/2007	A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion	Y	2.5 3.7.1
1.209, 03/2007	Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants	Y	3.11.2 7.1.3.4.21
1.216, 08/2010	Containment Structural Integrity Evaluation for Internal Pressure Loadings Above Design-Basis Pressure	Y	3.8.1.2.5 3.8.2.2.5
1.221, R0	Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants	Y	3.3.2 3.5
Division 4 Regulatory Guides			
4.1, R1	Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants	N/A-COL	N/A
4.2, R2	Preparation of Environmental Reports for Nuclear Power Stations	N/A-COL	N/A
4.2S1, 09/2002	Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Reports for Applications To Renew Nuclear Power Plant Operating Licenses	N/A-COL	N/A
4.4, 05/1974	Reporting Procedure for Mathematical Models Selected To Predict Heated Effluent Dispersion in Natural Water Bodies	N/A-COL	N/A
4.7, R2	General Site Suitability Criteria for Nuclear Power Stations	N/A-COL	N/A
4.8, 12/1975	Environmental Technical Specifications for Nuclear Power Plants	N/A-COL	N/A
4.11, R1	Terrestrial Environmental Studies for Nuclear Power Stations	N/A-COL	N/A

Table 2.1-1—U.S. EPR Site Design Envelope
Sheet 3 of 7

U.S. EPR Site Design Envelope	
Soil Density (γ) (in situ and backfill)	$110\ lb/ft^3 \le \gamma \le 134\ lb/ft^3$ (See Note 7)
Maximum Ground Water	3.3 ft below grade
Minimum Coefficient of Static Friction for Category I Structures (representative of all interfaces between basemat and soil)	0.5
NAB Coefficients of Friction	$0.5 \le \mu \le 0.7$
EPGB Coefficient of Side Wall Friction	$\mu \ge 0.36$
Inventory of Radionuclides Which Could Potentially Seep Into the Groundwater	
See Table 2.1-2—Bounding Values for Component Radionuclide Inventory	
Flood Level (Refer to Section 2.4)	
Maximum Flood (or Tsunami)	1 ft below grade
Wind (Refer to Section 3.3)	
Maximum Speed (Other than Tornado and Hurricane)	145 mph (Based on 3-second gust at 33 ft above ground level and factored for 50-yr mean recurrence interval)
Importance Factor	1.15 (Safety-related structures for 100-year mean recurrence interval.)
Tornado (Refer to Sections 3.3 and 3.5)	
Maximum Pressure and Rate of Drop	1.2 psi at 0.5 psi/s
Maximum Rotational Speed	184 mph

Table 2.1-1—U.S. EPR Site Design Envelope
Sheet 4 of 7

U.S. EPR Site Design Envelope	
Maximum Translational Speed	46 mph
Maximum Wind Speed	230 mph
Radius of Maximum Rotational Speed	150 ft
Missile Spectra	6 in Schedule 40 pipe, 6.625 in diameter x 15 ft long, 287 lb, 34.5 in^2 impact area, impact velocity of 135 fps horizontal and 90 fps vertical.
	Automobile, 16.4 ft x 6.6 ft x 4.3 ft, 4000 lb, 4086.7 in^2 impact area, impact velocity of 135 fps horizontal and 90 fps vertical. (Automobile missile is considered at elevations up to 30.0 ft above grade elevation.)
	Solid steel sphere, 1 in diameter, 0.147 lb, 0.79 in^2 impact area, impact velocity of 26 fps horizontal and 17 fps vertical.
Hurricane (Refer to Sections 3.3 and 3.5)	
Maximum Wind Speed	230 mph
Missile Spectra	6 in Schedule 40 pipe, 6.625 in diameter x 15 ft long, 287 lb, 34.5 in^2 impact area, impact velocity of 176 fps horizontal and 85 fps vertical.
	Automobile, 16.4 ft x 6.6 t x 4.3 ft, 4000 lb, 4086.7 in^2 impact area, impact velocity of 222 fps horizontal and 85 fps vertical. (Automobile missile is considered at elevations up to 30.0 ft above grade elevation).
	Solid steel sphere, 1 in diameter, 0.147 lb, 0.79 in^2 impact area, impact velocity of 155 fps horizontal and 85 fps vertical.

2.3 Meteorology

The U.S. EPR design is based on meteorological parameters (e.g., air temperature extremes, humidity, precipitation such as rainfall, snow and ice, maximum wind speeds, tornado and hurricane wind speeds, and atmospheric stability characteristics) provided in Section 2.1, Table 2.1-1—U.S. EPR Site Design Envelope. If a COL applicant that references the U.S. EPR design certification identifies site-specific meteorology values outside the range of the site parameter in Table 2.1-1, then the COL applicant will demonstrate the acceptability of the site-specific values in the appropriate sections of the Combined License application.

2.3.1 Regional Climatology

The following information is provided in Section 2.1, Table 2.1-1:

- Sum of normal winter precipitation event and extreme frozen winter precipitation event ground load.
- 100-year, 3-second gust wind speed.
- Tornado and Hurricane parameters.
- Dry bulb and wet bulb temperatures.

2.3.1.1 Basis for Meteorological Parameters

The site parameters for the dry-bulb and wet-bulb temperatures are based on the EPRI ALWR Utility Requirements Document (Reference 1) and available Early Site Permit applications. The two percent annual exceedance dry and wet bulb temperature values, as recommended by RG 1.206 and SRP 2.3.1, are not provided in Table 2.1-1. However, the two percent annual exceedance dry and wet bulb temperature values are bounded by the provided zero percent annual exceedance and one percent annual exceedance dry and wet bulb temperature values.

SRP 2.3.1 and RG 1.206 also recommend that the 100-year maximum dry bulb and coincident wet bulb temperature values, the 100-year maximum non-coincident wet bulb temperature value, and the 100-year minimum dry bulb temperature values be provided. Instead, the zero percent exceedance values for these parameters have been provided. Zero percent exceedance values are based on conservative estimates of 100-year return period values and historic extreme values, whichever is bounding.

The prescribed loads included in the combination of normal live loads are based on the weight of the normal winter precipitation event recorded at ground level. Winter precipitation loads to be included in the combination of extreme live loads is based on the addition of the weight of the extreme frozen or liquid precipitation event, codes and standards, and applicable quality control program for each component is provided in Section 3.2.

To address the broader ~~concept~~ definition of important to safety in the context of GDC 1, non-safety-related, risk significant SSC identified by the reliability assurance program (RAP) will be subject to the additional QA measures, as described in Section 17.4.2.

3.1.1.2 Criterion 2 – Design Bases for Protection Against Natural Phenomena

"Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of the capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena, and (3) the importance of the safety functions to be performed."

3.1.1.2.1 U.S. EPR Compliance

The safety-related SSC are designed either to withstand the effects of natural phenomena without loss of the capability to perform their safety functions, or to fail in a safe condition. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in Chapter 2. The U.S. EPR design criteria for wind, tornado, hurricane, flood, and earthquakes are discussed in Section 3.3, Section 3.4, and Section 3.7, respectively.

The U.S. EPR design envelopes the natural phenomena of expected sites. The design bases for safety-related SSC reflect this envelope of natural phenomena, including appropriate combinations of the effects of normal and accident conditions. Seismic and other design classifications, as well as other pertinent standards and information, are provided in the sections that discuss individual SSC.

To address the broader ~~concept~~ definition of important to safety in the context of GDC 2, SSC credited in the PRA analysis of external events are qualified for natural phenomena, as described in Sections 19.1.5.1 and 19.1.5.4.

3.1.1.3 Criterion 3 – Fire Protection

"Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat resistant materials shall be used

3.3 Wind, Hurricane and Tornado Loadings

Seismic Category I structures are designed to withstand the effects of wind, hurricane, and tornado loadings. A combined license (COL) applicant that references the U.S. EPR design certification will determine site-specific wind, hurricane, and tornado characteristics and compare these to the standard plant criteria. If the site-specific wind, hurricane, and tornado characteristics are not bounded by the site parameters, postulated for the certified design, then the COL applicant will evaluate the design for site-specific wind, hurricane, and tornado events and demonstrate that these loadings will not adversely affect the ability of safety-related structures to perform their safety functions during or after such events.

3.3.1 Wind Loadings

The U.S. EPR wind pressure loads are determined in conformance with ASCE/SEI Standard 7-05, "Minimum Design Loads for Buildings and Other Structures" (Reference 1). A COL applicant that references the U.S. EPR design certification will demonstrate that failure of site-specific structures or components not included in the U.S. EPR standard plant design, and not designed for wind loads, will not affect the ability of other structures to perform their intended safety functions.

3.3.1.1 Design Wind Velocity

The design basic wind speed is a 3-second gust speed at 33 feet above ground. The basic wind speed (V) is 145 mph in open terrain, exposure category C associated with a 50-year mean recurrence interval. The basic wind speed is increased by an importance factor of 1.15 to obtain a 100-year mean recurrence interval for the design of safety-related and quality-related structures.

3.3.1.2 Determination of Applied Wind Forces

Wind velocity is converted into an effective pressure to be applied to surfaces of structures in conformance with Reference 1.

Effective wind design velocity pressure (q_z) on structural elements is calculated in conformance with Reference 1, Equation 6-15, as follows:

$$q_z = 0.00256\ K_z\ K_{zt}\ K_d\ V^2\ I\ (\text{lb/ft}^2),$$

Where:

q_z = velocity pressure in pounds per square foot at height "z".

K_z = velocity pressure exposure coefficient at height "z" for Exposure Category C, which is determined in conformance with Reference 1,Table 6-3, but not less than 0.87.

K_{zt} = topographic factor = 1.0 for U.S. EPR standard plant design.

K_d = wind directionality factor = 1.0 for U.S. EPR standard plant design.

V = basic wind speed in miles per hour = 145 mph.

I = importance factor = 1.15 for safety-related and quality-related structures, systems and components (SSC). The importance factor is used to adjust the velocity pressure, q_z, to the appropriate 100-year mean recurrence interval for design of safety-related and quality-related SSC.

Effective pressure loads on structural elements and members are determined in conformance with the applicable requirements of Reference 1, Sections 6.5.12 through 6.5.15. Gust factors are applied in accordance with requirements of this standard.

ASCE paper No. 3269, "Wind Forces on Structures" (Reference 2) is used to determine the external pressure coefficients for distribution of wind pressures around the circumferences of the Reactor Shield Building and the vent stack.

3.3.2 Extreme Wind Loads (Hurricanes and Tornadoes)

Seismic Category I structures are designed to resist hurricane and tornado loadings and remain functional during and following a hurricane or tornado event. In addition, Non-Seismic Category I structures, that have the potential to interact with Seismic Category I structures are evaluated to demonstrate they do not affect Seismic Category I structures under hurricane and tornado load conditions. Hurricane and tornado loads are applied to the roofs and exterior walls of such structures. For Radwaste Seismic Structures, classified as RW-IIa per RG 1.143, additional hurricane and tornado loadings also apply, as specified in RG 1.143.

A COL applicant that references the U.S. EPR design certification will demonstrate that failure of site-specific structures or components not included in the U.S. EPR standard plant design, and not designed for hurricane and tornado loads, will not affect the ability of other structures to perform their intended safety functions.

Tornado wind loads include loads caused by the tornado wind pressure (W_w), tornado atmospheric pressure change effect (W_p), and tornado-generated missile impact (W_m). Hurricane wind loads include loads due to the hurricane wind pressure (W_w) and hurricane generated missiles (W_m). One hundred percent of the design live load is considered with tornado load combinations. Refer to Section 3.8 for loading combinations and acceptance criteria for hurricane and tornado loads considered in combination with other loads. Refer to Section 3.5 for a description of hurricane and tornado wind-generated missile loads and design criteria.

Local damage, such as cracking and spalling of concrete and permanent deformation of structural members and elements, is permissible when structures are designed for hurricane and tornado missile impact loads, provided that Seismic Category I structures remain functional during and subsequent to the missile strike. Structural integrity is demonstrated for all Seismic Category I structures as a result of hurricane and tornado wind-generated missile impact analysis, see Section 3.5.1.4. No adverse effects, such as concrete spalling and cracking, occur as a result of secondary missiles.

3.3.2.1 Applicable Hurricane and Tornado Design Parameters

The following parameters, determined in conformance with RG 1.76, are used for the design basis tornado:

- Radius of maximum rotational speed = 150 ft.
- Maximum wind speed = 230 mph.
- Maximum rotational speed = 184 mph.
- Maximum translational speed = 46 mph.
- Maximum pressure drop = 1.2 psi.
- Rate of pressure drop = 0.5 psi/s.

The following parameter, determined in conformance with RG 1.221, is used for the design basis hurricane:

- Maximum wind speed = 230 mph.

The design basis hurricane and tornado for the U.S. EPR standard plant design are selected for the majority of the contiguous United States (except limited territory along the East Coast and the Gulf of Mexico)~~a worst-case site in the contiguous United States~~, and represents a probability of exceedance of 1 x 10^{-7} per year.

3.3.2.2 Determination of Hurricane and Tornado Forces on Structures

Hurricane and tornado wind velocities are converted into effective pressure loads in accordance with Reference 1 and with guidance provided in NUREG 0800, SRP Section 3.3.2.

Effective hurricane or wind velocity pressure, q_z, is calculated as follows:

$$q_z = 0.00256\, K_z\, K_{zt}\, K_d\, V^2\, I\ (\text{lb/ft}^2),$$

Where:

q_z = velocity pressure in pounds per square foot at height “z.”

K_z = velocity pressure exposure coefficient at height, z, for Exposure Category C, from Table 6-3 (Reference 1), but not less than 0.87 for hurricane; 0.87, for wind (velocity pressure is considered constant with height).

K_{zt} = 1.0, a topographic factor of unity is used because hurricane and tornado maximum wind speeds are not determined based on site topography.

K_d = 1.0, a wind directionality factor of unity is used.

V = 230 mph, hurricane and tornado maximum wind speed (in miles per hour).

I = 1.15, importance factor.

Effective hurricane and tornado wind pressure loads (W_w) on exterior surfaces of structural elements and members are determined in conformance with the applicable requirements of Reference 1, Sections 6.5.12 and 6.5.13. Gust factors are taken as unity for tornado wind and 0.85 for hurricane wind.

Tornado atmospheric pressure change effect parameters (W_p) and tornado-generated missile impact parameters (W_m) are in conformance with RG 1.76. Hurricane-generated missile impact parameters (W_m) are in conformance with RG 1.221.

The following combinations of the parameters of the total hurricane or tornado load (W_t) are evaluated in the design of Seismic Category I structures and Seismic Category II structures, where W_w is the load from tornado or hurricane wind effect, W_p is the load from tornado atmospheric pressure change effect (the hurricane pressure change can be considered to be negligible), and W_m is the load from tornado or hurricane missile impact effect:

$$W_t = W_p$$

$$W_t = W_w + 0.5W_p + W_m \quad (W_p\text{=0 for hurricane})$$

Exterior walls and roofs of Seismic Category I structures are designed for the maximum differential pressure of 1.2 psi. When the tornado pressure boundary is not established by exterior walls or roofs, the differential pressure is taken as zero.

3.3.2.3 Interaction of Non-Seismic Category I Structures with Seismic Category I Structures

The non-Seismic Category I structures that are adjacent to the Seismic Category I Nuclear Island Common Basemat Structure, Emergency Power Generation Buildings (EPGB), and Essential Service Water Buildings (ESWB) include the Nuclear Auxiliary Building (NAB), Radioactive Waste Building (RWB), Access Building (ACB), and Turbine Building (TB). Figure 3B-1 provides a site plan of the U.S. EPR standard plant showing the plant layout.

The NAB is a non-Seismic Category I structure. However, due to the proximity of this structure to Seismic Category I structures, there is potential for extreme wind load induced interaction. Therefore, this structure is analyzed using RG 1.76 tornado wind characteristics and RG 1.221 hurricane wind characteristics and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the NAB does not have a safety function, the NAB may slide or uplift provided that the gap between the NAB and any Category I structure is adequate to prevent interaction.

The ACB, and TB are non-Seismic Category 1 structures. However, due to proximity of these structures to Seismic Category 1 structures there is a potential for extreme wind load induced interaction. [[Therefore, these structures are analyzed using RG 1.76 tornado wind characteristics and RG 1.221 hurricane wind characteristics and designed to the codes and standards associated with Seismic Category I structures so that the margin of safety is equivalent to that of a Category I structure with the exception of sliding and overturning criteria. Because the ACB, and TB do not have a safety function, they may slide or uplift provided that the gap between them and any Category I structure is adequate to prevent interaction.]]

The RWPB is a reinforced concrete shear wall structure designed for tornado and hurricane loadings per RG 1.143 due to its classification as a RW-IIa structure. The NAB is a reinforced concrete structure located between the RWPB and the NI. Both the RWPB and the NAB are designed using the codes associated with Category I structures, resulting in inherently robust designs. Therefore, there is no potential for indirect interaction between the RWPB and the NI structures. Potential interaction between the RWB and the EPGB is precluded by separation and design. The RWB is embedded over 31.5 ft below grade and has a clear height above grade of 52.5 ft; whereas, the clearance between the two structures is 52.06 ft.

3.3.3 References

1. ASCE/SEI Standard 7-05, "Minimum Design Loads for Buildings and Other Structures," American Society of Civil Engineers/Structural Engineering Institute, 2005.

2. ASCE paper No. 3269, "Wind Forces on Structures," Transactions of the American Society of Civil Engineers, Vol. 126, Part II, 1961.

3. Deleted.

4. Deleted.

5. Deleted.

Next File

3.5 Missile Protection

In support of General Design Criteria 2 and 4 of Appendix A to 10 CFR 50, safety-related structures, systems and components (SSC) on the plant site and the containment are protected from externally and internally generated missiles. Safety-related SSC are designed and constructed so as not to fail or cause a failure in the event of a postulated credible missile impact. These SSC include some, which, if they fail, could cause the failure of the integrity of the reactor coolant system (RCS), the reduction to an unacceptable level of any plant feature required for safe shutdown of the reactor, or lead to offsite radiological consequences. The recommendations of RG 1.13, RG 1.27, RG 1.76, RG 1.115, ~~and~~ RG 1.117, and RG 1.221 as they pertain to internally and externally generated missiles, are met. Missile protection is provided by:

- Locating the system or component in a missile-proof structure.
- Separating redundant systems or components from the missile path or range.
- Providing local shields and barriers for systems and components.
- Designing the equipment to withstand the impact of the most damaging missile.
- Providing design features to prevent the generation of missiles.
- Orienting missile sources to prevent missiles from striking safety-related equipment.

Some missiles may be determined to be non-credible by demonstrating that the event is not statistically significant if the product of the probability of missile occurrence, probability of impact on a significant target, and probability of significant damage is less than 1×10^{-7} per year. To the extent practical, equipment required for safe shutdown of the U.S. EPR is located in areas of the plant separate from potential sources of missiles. Four redundant trains of safety-related components are provided, which are housed in the four separate Safeguard Buildings, the Emergency Power Generation Buildings (EPGB), and the Essential Service Water Buildings (ESWB) which houses the Essential Service Water Cooling Tower Structures (ESWCT) and the Essential Service Water Pump Buildings (ESWPB). In the case that missile creation cannot be prevented, missile barriers are provided to preclude damage to SSC required to achieve safe shutdown or to those SSC that are required to prevent the release of radioactivity producing offsite doses greater than prescribed limits. Missile barriers are composed of walls, partitions, component housings, and other items that enclose safety-related systems or separate redundant trains of safety-related systems.

Postulated missile impacts are assumed to occur in conjunction with single active failures of the SSC used to attain safe shutdown of the plant. A single active failure is the failure of an electrical or fluid system component as a result of mechanical, hydraulic, pneumatic or electrical malfunction, without the loss of the structural integrity of the component. If a missile is generated in any of the redundant trains of a safety-related fluid system that is a Seismic Category I system and is capable of being powered from both onsite and offsite sources, a single active failure is not assumed in the remaining or associated supporting trains.

In the event that a missile is generated simultaneously with a single active failure, evaluations are performed to confirm that missile protection requirements are satisfied. Assessments are made of the missile size, energy, and potential path. Potentially impacted components associated with systems that are required to attain safe shutdown are analyzed to identify any at-risk items that may be within the postulated path and impact zone of the missile. Evaluations are performed to assess the loss of potentially impacted components, concurrent with a single active failure. These evaluations consider redundancy provided for safe shutdown equipment to determine if loss of the component due to missile impact and single active failure is acceptable. If this requirement is satisfied, no further protection from the missile is necessary.

Section 3.7.3 describes design of the non-seismic SSC which, if they fail, could potentially create seismic-generated missiles that could affect safety-related SSC. Section 9.1.5 describes evaluation of overhead lifting devices which, if they fail, could cause heavy-load drop impact events. Chapter 7 describes SSC required for safe shutdown of the U.S. EPR. Section 3.2 describes the quality classifications of SSC. Section 1.2 provides general arrangements and identification of U.S. EPR structures. U.S. EPR structures that house safe shutdown systems and components and require missile protection are identified in Section 3.5.2.

The following sections provide the bases for the selection of missiles and protection requirements for internal and external missiles.

3.5.1 Missile Selection and Description

The U.S. EPR design is based upon consideration of the following potential missile generating sources:

- Internally generated missiles (outside containment) (Section 3.5.1.1).
- Internally generated missiles (inside containment) (Section 3.5.1.2).
- Turbine missiles (Section 3.5.1.3).
- Missiles generated by ~~tornadoes and~~ extreme winds (Section 3.5.1.4).
- Site proximity missiles (except aircraft) (Section 3.5.1.5).
- Aircraft hazards (Section 3.5.1.6).

storage area for plant gases is situated a sufficient distance from the Nuclear Island (NI) so that a hydrogen explosion could not create more hazardous missiles than the tornado and hurricane missile spectra that the plant is designed to resist. Battery compartments are ventilated to prevent an accumulation of hydrogen gas. Hydrogen supply lines are routed through compartments with non-safety-related systems and components. Plant heating, ventilation, and air conditioning systems provide air movement.

The effects of potential internally generated missiles are minimized by the separation and the redundancy of safety-related systems throughout the U.S. EPR. Four Safeguard Buildings provide operability of vital plant systems in the event that problems or maintenance occur simultaneously in up to three of the Safeguard Building areas. Redundancy and separation are provided by the four emergency diesel generators (EDG) and four Ultimate Heat Sink (UHS) and Essential Service Water (ESW) trains.

Missile barriers are provided between redundant trains of equipment that are housed adjacent to one another. Section 3.5.3 describes missile barrier design procedures. Components within one train of a system with redundant trains need not be protected from missiles originating from within the same train.

A COL Applicant that references the U.S. EPR design certification will describe controls to confirm that unsecured maintenance equipment, including that required for maintenance and that are undergoing maintenance, will be either removed or seismically supported when not in use to prevent it from becoming a missile.

3.5.1.2 Internally Generated Missiles Inside Containment

The following sections describe credible and non-credible internally generated missile sources and missile prevention and protection inside containment.

3.5.1.2.1 Credible Internally Generated Missile Sources Inside Containment

Credible internally generated missile sources inside containment are similar to those identified in Section 3.5.1.1.1, including the failure of rotating equipment and pressurized components in high energy systems. Internally generated missiles inside containment are not postulated to occur simultaneously with other plant accidents.

Missile protection is based on the energy created from rotating components at a 120 percent overspeed condition, unless other conditions exist that limit the potential for overspeed.

Any fluid system that is pressurized with a maximum operating temperature greater than 200°F or a maximum operating pressure greater than 275 psig during normal plant operation is considered a potential source for missile generation.

3.5.1.4 Missiles Generated by Extreme Winds

Hurricane-generated and tornado-generated missiles are evaluated in the design of safety-related structures. Hurricane-generated and tornado-generated missiles evaluated for their impact on safety-related structures conform to the Region I missile spectrum presented in Table 2 of RG 1.76 and Tables 1 and 2 of RG 1.221. These spectra are based on the design basis hurricane and tornado defined in Section 3.3 and represents a probability of exceedance event of 1 x 10^{-7} per year.

The selected missiles for U.S. EPR include:

- A massive high-kinetic-energy missile that deforms on impact, such as an automobile.
- A rigid missile that tests penetration resistance, such as a six-inch diameter Schedule 40 pipe.
- A small rigid missile of a size that is sufficient to pass through openings in protective barriers, such as a one-inch diameter solid steel sphere.

The missiles considered in the U.S. EPR design are listed in Table 3.5-1—Spectra of Design Basis Tornado and Hurricane Missiles.

The automobile missile is considered to impact at altitudes that are less than 30 ft above plant grade.

A COL applicant that references the U.S. EPR design certification will evaluate the potential for other missiles generated by natural phenomena, such as hurricane and tornado winds, and their potential impact on the missile protection design features of the U.S. EPR.

For sites with surrounding ground elevations that are higher than plant grade, a COL applicant that references the U.S. EPR design certification will confirm that automobile missiles cannot be generated within a 0.5 mile radius of safety-related SSC that would lead to impact higher than 30 ft above plant grade.

3.5.1.5 Site Proximity Missiles (Except Aircraft)

A COL applicant that references the U.S. EPR design certification will evaluate the potential for site proximity explosions and missiles generated by these explosions for their potential impact on missile protection design features. Evaluation of design basis threat (DBT) explosions near the U.S. EPR required by 10 CFR 73.55 is considered as a part of the plant safeguards and security measures and is not described in this document.

Safety-related pipes and cables routed outside of missile-protected structures are buried a sufficient depth to provide protection for these items from missile impact, or concrete or steel enclosures are provided that are designed to withstand missile impact loads.

The externally generated missiles for which the U.S. EPR is designed are addressed in Section 3.5.1.

Section 3.3.2.3 describes the evaluation of the effects that the failure of structures or components not designed for tornado and hurricane loads, including missile impact, could have on nearby safety-related structures. Section 3.7.3 describes design requirements for Seismic Category II SSC, which are designed not to fail as a result of a safe shutdown earthquake and generate missiles that could affect the function of safety-related SSC.

Structures used to protect safety-related SSC meet the requirements of the following regulatory guides for externally generated missiles:

- Turbine generated missiles (RG 1.115).
- Tornado generated missiles (RG 1.117).
- Hurricane generated missiles (RG 1.221).
- Spent fuel storage facility (RG 1.13).
- Ultimate Heat Sink (RG 1.27).

3.5.3 Barrier Design Procedures

Missile barriers are designed to withstand local and overall effects of missile impact loadings. No credit is taken for non-safety-related structures providing shielding for safety-related structures from missile strikes.

Safety-related SSC are protected from missile penetration through the barrier, as well as from secondary missiles as a result of back-face scabbing. [*Concrete missile barriers subject to impactive loads are designed in accordance with the requirements of Appendix C to ACI 349 (Reference 1).*]* The Modified National Defense Research Committee Formulas referenced in ASCE No. 58, "Structural Analysis and Design of Nuclear Plant Facilities" (Reference 2) are used for the evaluation of missile penetration.

Steel missile barriers subject to impactive loads are designed in accordance with the recommendations of NUREG-0800, Reference 10. The Ballistic Research Laboratory (BRL) formula and the Stanford Research Institute (SRI) equation presented in ASCE No. 58, Reference 2, are used in the design of steel missile barriers to provide

- average bullet nose (spherical end) = 1.00.
- very sharp nosed bodies = 1.14.

W = missile weight (pounds).

v_0 = missile impact velocity (feet per second).

d = effective missile diameter (inches); for non-solid cylindrical shaped missiles, d is the diameter of an equivalent solid cylindrically-shaped missile with the same contact surface area as the contact surface of the actual missile, for example, d = $\sqrt{4A_c/\pi}$.

A_c = missile contact area, (square inches).

3.5.3.1.1.2 Perforation

The relationship for perforation thickness, e, and penetration depth, x, is determined from the following formulas:

$$\frac{e}{d} = 1.32 + 1.24\frac{x}{d}, \quad \text{for } 1.35 \le \frac{x}{d} \le 13.5$$

$$\frac{e}{d} = 3.19\left(\frac{x}{d}\right) - 0.718\left(\frac{x}{d}\right)^2, \quad \text{for } \frac{x}{d} \le 1.35$$

3.5.3.1.1.3 Scabbing

The relationship for scabbing thickness, s, and penetration depth, x, is determined from the following formulas:

$$\frac{s}{d} = 2.12 + 1.36\frac{x}{d}, \quad \text{for } 0.65 \le \frac{x}{d} \le 11.75$$

$$\frac{s}{d} = 7.91\left(\frac{x}{d}\right) - 5.06\left(\frac{x}{d}\right)^2, \quad \text{for } \frac{x}{d} \le 0.65$$

Table 3.5-2—Minimum Concrete Barrier Thickness Requirements for Local Damage Prediction against Tornado and Hurricane Generated Missiles, shows minimum concrete barrier thickness requirements for local damage prediction against tornado-generated missiles, which are based on the Region I guidelines in NUREG-0800, Reference 10. The same guideline is used for hurricane-generated missiles.

All indicated changes are in response to RAI 541, Question 02-3

Table 3.5-1—Spectra~~um~~ of Design Basis Tornado and Hurricane Missiles

Missile Descriptions	Dimensions	Weight	Impact Area[1]	Tornado Design Impact Velocity[2]		Hurricane Design Impact Velocity	
				Horizontal	Vertical	Horizontal	Vertical
6 in Sch. 40 Pipe	6.625 in ϕ x 15.0 ft	287 lb	34.5 in^2	135 ft/s	90 ft/s	176 ft/s	85 ft/s
Automobile	16.4 ft x 6.6 ft x 4.3 ft	4000 lb	4086.7 in^2	135 ft/s	90 ft/s	222 ft/s	85 ft/s
Solid Steel Sphere	1 in ϕ	0.147 lb	0.79 in^2	26 ft/s	17 ft/s	155 ft/s	85 ft/s

Notes:

1. Barrier design evaluates impact loads assuming the missile longitudinal axis impacts normal to the barrier surface.
2. Vertical velocities are equal to 67% of the horizontal velocities.

Table 3.5-2—Minimum Concrete Barrier Thickness Requirements for Local Damage Prediction against Tornado and Hurricane Generated Missiles

Concrete Strength	Wall Thickness	Roof Thickness
3000 psi	18.2 in	13.2 in
4000 psi	16.9 in	12.3 in
5000 psi	16.0 in	11.7 in

Safety-related buried conduit, duct banks, pipes and pipe ducts are installed Seismic Category I to support and protect safety-related distribution systems outside of the NI Common Basemat Structure.

The dimensional arrangement drawings for Seismic Category I structures are provided in Appendix 3B.

3.8.1 Concrete Containment

The RCB is part of the RB system as illustrated in Figure 3B-1. The RCB controls the release of airborne radioactivity following postulated design basis accidents (DBA) and provides radiation shielding for the reactor core and the RCS. The RCB is a post-tensioned concrete pressure vessel and is located inside the reinforced concrete RSB described in Section 3.8.4. This section addresses the concrete elements of the RCB. Section 3.8.2 addresses steel sub-elements of the RCB (e.g., the equipment hatch and other penetrations). Section 6.2 describes the functional aspects of the containment system (e.g., heat removal, containment isolation, combustible gas control and leakage testing).

3.8.1.1 Description of the Containment

Figure 3.8-1—Reactor Building Plan at Elevation -50 Feet, Figure 3.8-2—Reactor Building Plan at Elevation -20 Feet, Figure 3.8-4—Reactor Building Plan at Elevation +5 Feet, Figure 3.8-5—Reactor Building Plan at Elevation +17 feet, Figure 3.8-6—Reactor Building Plan at Elevation +29 feet, Figure 3.8-7—Reactor Building Plan at Elevation +45 feet, Figure 3.8-8—Reactor Building Plan at Elevation +64 feet, Figure 3.8-9—Reactor Building Plan at Elevation +79 feet, Figure 3.8-10—Reactor Building Plan at Elevation +94 feet, Figure 3.8-11—Reactor Building Section A-A, and Figure 3.8-13—Reactor Building Section C-C show plan and section views of the RCB. See Sections 3.8.3 and 3.8.4 for additional figures showing structures adjacent to the RCB.

The RCB is located inside the reinforced concrete RSB. The RSB protects the containment structure from external hazards (e.g., wind loads, tornado and hurricane loads, aircraft hazard, explosion pressure wave and missiles). An annular space, designated as the RB annulus, is provided between the RCB and the RSB to prevent interaction of the two structures when subjected to extreme postulated design basis and beyond design basis loading conditions.

The RCB houses the RB internal structures. To prevent adverse interactions inside the RCB, the RB internal structures are physically independent of the RCB, except at the supporting foundation basemat. No structural connections are provided between the RCB and the RB internal structures. The RCB also provides structural support for the polar crane.

- Test Thermal Loads (T_t) – Test thermal loads include thermal effects and loads experienced by the RCB during the structural integrity and leak-rate tests.

Factored Loads

- Severe Environmental Loads – Severe environmental loads are those loads that could be encountered infrequently during the life of the plant (GDC 2). This load category includes:
  - Wind Loads (W) – There are no wind loads applicable on the RCB because it is surrounded by other Seismic Category I structures that subsequently provide a shield.
  - There are no operating basis earthquake (OBE) loads applicable to the overall RCB design for the U.S. EPR because an OBE level of one-third the SSE has been selected. See Section 3.7.1 for a description of the OBE.
- Extreme Environmental Loads – Extreme environmental loads are those that are credible but are highly improbable (GDC 2). This load category includes:
  - SSE (E') – SSE loads are those loads generated by an earthquake with a peak horizontal ground acceleration of 0.30g. Seismic loads in the vertical direction and two orthogonal horizontal directions are considered to act simultaneous. Section 3.7 provides a description of how SSE loads are determined and combined. SSE loads are considered due to applied inertia loads, including dead loads, live loads, and hydrodynamic loads (i.e., water in storage pools and tanks).
  - Tornado and Hurricane Loads (W_t) – Loads generated by the design basis tornado and hurricane are described in Section 3.3 and Section 3.5. This load category includes:
    - Tornado and Hurricane Wind Pressure (W_w) – Tornado and Hurricane wind pressure is not applicable because the RCB is protected from wind forces by the RSB.
    - Tornado and Hurricane Created Differential Pressure (W_p) – The RSB is designed as an enclosed, unvented structure, which does not allow tornado differential pressure forces to affect the RCB (W_p) = 0 for hurricane.~~.~~
    - Tornado and Hurricane Generated Missiles (W_m) – Tornado and Hurricane-generated missile loads are not applicable because the RSB serves as a barrier to protect the RCB from missile strikes.
- Abnormal Loads – Abnormal loads are those loads generated by a postulated high-energy pipe break accident. This event is classified as a DBA (GDC 4 and GDC 50). These loadings include an appropriate dynamic load factor to account for the dynamic nature of the load, unless a time-history analysis is performed to justify otherwise. Abnormal loads include the following loads:

evaluation of this loading condition is considered as part of the plant safeguard and security measures. Explosion pressure wave loads are not applicable on the RCB because it is surrounded by other Seismic Category I structures that provide a shield.

- Combustible Gas (C) – Combustible gas loads are pressure loads that result from a fuel-clad metal-water reaction followed by an uncontrolled hydrogen burn during a post-accident condition in a reactor containment (Refer to Section 6.2.5).

Missile Loads other Than ~~Wind- or~~ Hurricane- or Tornado-Generated Missiles

There are no missile loads on the RCB resulting from activities of nearby military installations, turbine failures, or other causes. The RCB is surrounded by other Seismic Category I structures that shield it from missiles.

3.8.1.3.2 Design Load Combinations

Loading combinations used for the design of the RCB, including its steel liner plate, are in accordance with guidance provided in NUREG-0800, Standard Review Plan, Section 3.8.1 (Reference 3) (GDC1, GDC 2, GDC 4, GDC 16, and GDC 50).

The NI Common Basemat Structure is a monolithic concrete structure. However, various portions of the structure have different classifications (i.e., RCB, RB internal structures, and other Seismic Category I structures) and correspondingly different design requirements, as shown in Figure 3.8-118. In some instances, the load combinations identified in NUREG-0800 do not include certain independent loadings which should be considered to account for potential structure-to-structure effects (i.e., the effect on one structure resulting from loadings applied to a separate, but monolithically connected, structure). To account for potential structure-to-structure effects, the NUREG-0800 loading combinations are adjusted by including the necessary additional independent loadings. The independent loadings added to the load combinations include hydrostatic load (F), buoyant force (F_b), and soil load/lateral earth pressure (H). The load factors for hydrostatic load (F) and buoyant force (F_b) are matched to that of the dead load (D) for each loading combination, while the load factor for soil load/lateral earth pressure (H) is matched to that of the live load (L). Section 3.8.1.3.1 provides details regarding all loads considered for the design of the RCB.

The following guidance is used for applying load combinations for the design of the RCB:

- The live load (L) is applicable after construction of containment. Construction loadings, temporary or otherwise, may also be considered as live loads and included within appropriate loading combinations.

structural elements, which provide space necessary to inspect the liner at wall and floor locations inside containment. Inservice inspection of the embedded portion of the containment liner and the surface of the concrete containment structure covered by the liner are exempted in accordance with Section III of the ASME Code for Class CC components.

3.8.2 Steel Containment

The steel containment section describes major RCB penetrations and portions of penetrations not backed by structural concrete that are intended to resist pressure. Section 3.8.1 describes the concrete RCB.

3.8.2.1 Description of the Containment

Steel items that are part of the RCB pressure boundary and are not backed by concrete include the equipment hatch, airlocks, construction opening, piping penetration sleeves, electrical penetration sleeves, and fuel transfer tube penetration sleeve. Section 3.8.1.1 describes RCB steel items that are backed by concrete, such as the liner plate.

3.8.2.1.1 Equipment Hatch, Dedicated Spare Penetration, Airlocks, and Construction Opening

The equipment hatch, illustrated in Figure 3.8-25 is a welded steel assembly with a double-sealed, flanged, and bolted cover. The cover for the equipment hatch attaches to the hatch sleeve from inside of the RCB. The cover seats against the sealing surface of the penetration sleeve mating flange when subjected to internal pressure inside the RCB. The RCB penetration sleeve and the RSB penetration sleeve are connected by an expansion joint to allow for differential movement between the two walls, as shown in Figure 3.8-25. The equipment hatch opens into the Seismic Category I FB, which provides protection of the hatch from external environmental hazards (e.g., high wind, tornado and hurricane winds and missiles, and other site proximity hazards, including aircraft hazards and blasts). The equipment hatch sleeve has an inside diameter of approximately 27 feet, 3 inches.

The containment penetrations also include a 36-inch diameter spare containment penetration as shown in Figure 3.8-119. This penetration is dedicated for post-accident conditions as described in Section 19.2.3.3.8.

One personnel airlock and one emergency airlock are provided for personnel to access the RCB. Figure 3.8-26—Personnel Airlock, Emergency Airlock General Overview illustrates a typical arrangement for the airlocks. Each airlock is a welded steel assembly that has two doors, each with double seals. The airlocks open into containment so that internal pressure inside the RCB seats the doors against their sealing surfaces. The personnel airlock and emergency airlock are connected to the RSB wall by expansion joints to allow for differential movement.

The doors mechanically interlock so that one door can not be opened unless the second door is sealed during plant operation. Provisions are made for deliberately overriding the interlocks by the use of special tools and procedures for ease of access during plant maintenance. Each door is equipped with valves for equalizing the pressure across the doors. The doors are not operable unless the pressure is equalized. Pressure equalization is possible from the locations at which the associated door can be operated. The valves for the two doors interlock so that only one valve can open at a time and only when the opposite door is closed and sealed. Each door is designed to withstand and seal against design and testing pressures of the containment vessel when the other door is open. A visual indication outside each door shows whether the opposite door is open or closed. In the event that one door is accidentally left open, provisions outside each door allow remote closing and latching of the opposite door.

The personnel airlock at [ ] opens into a [ ] which is a Seismic Category I structure. The emergency airlock opens into the [ ], which is a Seismic Category I structure. Therefore, both airlocks are protected from external environmental hazards (e.g., high wind, tornado and hurricane winds and missiles, and other site proximity hazards, including aircraft hazards and blasts). The personnel airlock and the emergency airlock have inside diameters of approximately 10 feet, 2 inches.

The construction opening is located at [ ] and opens to the heavy load operating floor level from [ ] This passage serves as personnel and material access into the RB during construction. The construction opening has an outside diameter of approximately 9 feet, 6 inches. Upon completion of construction work, the cavity in the RCB is permanently sealed with a metal closure cap welded to an embedded sleeve. The construction opening is shown in Figure 3.8-123.

[*The equipment hatch, dedicated spare penetration, two airlocks, and construction opening closure cap and sleeve are designated as Class MC components in compliance with Article NE-3000 of the ASME Code, Section III, Division I, and are stamped pressure vessels designed and tested in accordance with this code*]* (GDC 1 and GDC 16).

3.8.2.1.2 Piping Penetration Sleeves

Piping penetrations through the RCB pressure boundary are divided into the following three general groups:

- High-energy penetrations:

- Explosion pressure wave (B) – Explosion pressure wave refers to the loads on a structure resulting from an explosion in the vicinity of the structure. The evaluation of this loading condition is considered as part of the plant safeguards and security measures. Explosion pressure wave loads are not applicable to steel portions of the RCB because it is surrounded by other Seismic Category I structures that provide a shield.

- Combustible gas loads (P_g1 and P_g2) – Combustible gas loads are pressure loads that result from a fuel-clad metal-water reaction followed by an uncontrolled hydrogen burn during a post-accident condition in a reactor containment (refer to Section 6.2.5).

- Missile loads other than ~~wind or~~ hurricane- or tornado-generated missiles – Missile loads are not applicable to steel portions of the RCB resulting from activities of nearby military installations, turbine failures, or other causes. RCB and RSB penetrations are protected by other Seismic Category I structures (i.e., Safeguards or FBs).

3.8.2.3.2 Design Load Combinations

Loading combinations for steel items of the RCB that are not backed by concrete and are in accordance with Subsection NE of the ASME Code, Section III, Division 1, as augmented by the applicable provisions of RG 1.57 (GDC 1, GDC 2, GDC 4, GDC 16, and GDC 50).

The effects of missiles and external events such as hurricanes, tornados, aircraft hazards, and explosion pressure waves are not considered because the containment is protected from these effects by the RSB. RCB and RSB penetrations are protected by other Seismic Category I structures (i.e., Safeguards or FBs).

Loads and loading combinations encompass the soil cases described in Section 3.7.1, using the design criteria described in Section 3.7.1 and Section 3.7.2.

The following loading combinations are considered for ASME Code Class MC RCB components that are completely enclosed within Seismic Category I structures. Stress intensities will be computed in accordance with Article NE-3215 of the ASME Code III, Division 1.

Testing Load Combination

Where:

P^* = the set of calculated stress components associated with the analysis results for each load combination

$P^* = D + L + P_t + T_t.$

Severe Environmental Loads

Severe environmental loads are those loads that could be encountered infrequently during the life of the plant (GDC 2). The RB internal structures are protected by the RSB and the RCB; therefore, wind, earth pressure, or external flood loads do not apply. There are no OBE loads applicable to the overall design of the RB internal structures because an OBE level of one-third the SSE has been selected. See Section 3.7.1 for a description of the OBE. Severe environmental loads are not applicable to the design of RB internal structures.

Extreme Environmental Loads

Extreme environmental loads are those loads that are credible but are highly improbable (GDC 2). The RB internal structures are protected by the RSB and the RCB; therefore, tornado, hurricane, and external missile loads do not apply. This load category includes:

- Safe Shutdown Earthquake (E')—SSE loads are those loads generated by an earthquake with a peak horizontal ground acceleration of 0.30g. Seismic loads in the vertical direction and two orthogonal horizontal directions are considered to act simultaneously. Section 3.7 provides a description of how SSE loads are determined and combined. SSE loads are considered due to applied inertia loads, including dead loads, live loads, and hydrodynamic loads (i.e., water in storage pools and tanks), including combination of these loads using the square root of the sum of the squares (SRSS) method.

Abnormal Loads

Abnormal loads are those loads generated by a postulated high-energy pipe break causing a LOCA within a building or compartment (GDC 4 and GDC 50). This event is classified as a DBA. Included in this category are: Internal flooding loads (F_a), Pressure loads (P_a), Thermal loads (T_a), Accident pipe reaction loads (R_a), and Pipe break loads (R_r).

The Pipe break load is subcategorized as Pipe break reaction loads (R_{rr}), Pipe break jet impingement loads (R_{rj}), and Pipe break missile impact loads (R_{rm}). These loadings include a dynamic load factor to account for the dynamic nature of the load, unless a time-history analysis is performed to justify otherwise.

Abnormal loads include the following loads:

- Internal flood loads (F_a)—Loads resulting from internal flooding of containment during or following a postulated DBA.

- Pressure load (P_a)—Pressure equivalent static load within or across a compartment generated by the postulated pipe break and including a dynamic load factor to account for the dynamic nature of the load.

- Thermal load (T_a)—Thermal loads generated by the postulated pipe break and including T_o.

- Accident pipe reactions (R_a)—Pipe reactions generated by the postulated pipe break and including R_o.

- Pipe break loads (R_r)—Local equipment and piping loads generated following a postulated pipe break. Unless a time-history analysis is performed to justify otherwise, these loadings include a dynamic load factor to account for the dynamic nature of the load. The pipe break load (R_r) is considered to act as three separate components (R_{rr}, R_{rj}, R_{rm}), which are defined in the following paragraphs. In determining an appropriate equivalent static load for R_{rr}, R_{rj}, and R_{rm}, elasto-plastic behavior may be assumed with appropriate ductility ratios, provided excessive deflections do not result in the loss of function of any safety-related SSC.

  – Pipe break reaction loads (R_{rr})—R_{rr} is defined as the equivalent static load on the structure generated by the reaction of the high-energy pipe during the postulated break.

  – Pipe break jet impingement loads (R_{rj})—R_{rj} is defined as the jet impingement equivalent static load on the structure generated by the postulated break.

  – Pipe break missile impact loads (R_{rm})—R_{rm} is defined as the missile impact equivalent static load on the structure generated by or during the postulated break, such as pipe whipping.

Other Loads

Other loads refer to postulated events or conditions that are not included in the design basis (GDC 4). These loading conditions and effects are evaluated without regard to the bounding conditions under which SSC perform design basis functions. This load category includes:

- Aircraft hazard (A)—Aircraft hazard refers to loads on a structure resulting from the impact of an aircraft. The evaluation of this loading condition is considered as part of the plant safeguards and security measures. There are no aircraft hazard loads on the RB internal structures since they are surrounded by other Seismic Category I structures that shield them from these loads.

- Explosion pressure wave (B)—Explosion pressure wave refers to loads on a structure resulting from an explosion in the vicinity of the structure. The evaluation of this loading condition is considered as part of the plant safeguards and security measures. There are no explosion pressure wave loads on the RB internal structures because they are surrounded by other Seismic Category I structures that shield them from these loads.

- Missile loads other than ~~wind- or~~ hurricane- or tornado-generated missiles—The RSB and the RCB protect the RB internal structures from impact of externally generated missiles. The RB internal concrete and steel structures are designed for

The RSB is surrounded by SBs 1, 2, 3, 4, and by the FB, which are Seismic Category I safety-related structures. The walls and slabs of SBs 1 and 4 frame into the RSB cylindrical wall for support. The roofs and external walls of SBs 2 and 3 and the FB frame into the RSB wall for support; however, the interior walls and floors of these buildings are separated from the RSB to isolate the interior portions of the structures in the event of an aircraft hazard or blast loading event. Where they are enclosed within the SBs and the FB, the lower portions of the RSB cylindrical wall are approximately 4 feet, 3 inches thick. The RSB cylindrical wall and dome that are exposed to the environment above the roofs of the adjacent SBs and FBs are approximately 5 feet, 11 inches thick.

The Reactor Building (RB) annulus is the space between the RSB and the RCB. The annular space is approximately 5 feet, 11 inches wide between the faces of the concrete walls of the two buildings. The RB annulus is an area that provides access for personnel to inspect the outside of the RCB, and to route piping, ventilation ducts, electrical cables, and other items. A slight negative pressure is maintained in the annulus to facilitate the secondary function of the RSB as a barrier to the release of contamination.

Figure 3.8-3—Reactor Building Plan at Elevation -8 Feet (top of concrete at start of containment wall), Figure 3.8-4—Reactor Building Plan at Elevation +5 Feet (top of heavy floor for nuclear steam supply system (NSSS) component support), Figure 3.8-5—Reactor Building Plan at Elevation +17 feet (plan at centerline of reactor vessel piping nozzles), Figure 3.8-6—Reactor Building Plan at Elevation +29 feet (top of grating floor for component access), Figure 3.8-7—Reactor Building Plan at Elevation +45 feet (top of grating floor for component access), Figure 3.8-8—Reactor Building Plan at Elevation +64 feet (top of concrete operating floor), Figure 3.8-9—Reactor Building Plan at Elevation +79 feet (top of partial concrete floor), Figure 3.8-10—Reactor Building Plan at Elevation +94 feet (top of pressurizer cubicle), Figure 3.8-11—Reactor Building Section A-A, Figure 3.8-12—Reactor Building Section B-B, and Figure 3.8-13—Reactor Building Section C-C show the arrangements of the RSB and annulus.

3.8.4.1.2 Fuel Building

The FB is a reinforced concrete structure that extends approximately 58 feet out from the RSB wall by 160 feet long by 140 feet high. The FB is located on the side of the RSB that is opposite of SBs 2 and 3. Hardening of the exterior walls and roof of the FB protects it against external events (e.g., $\boxed{\text{hurricane and}}$ tornado missiles, aircraft hazard and blast loadings). Dual exterior walls are provided from the foundation up to the ceiling, except on either end of the FB where the stair towers are located, to isolate interior structures from the exterior walls in order to mitigate the effects of external events.

and 3. Each division of the SBs contains a redundant safety system train. The lower levels of the SBs house mechanical systems, while the upper levels contain electrical, instrumentation, controls, and heating, ventilation, and air conditioning (HVAC) systems. Emergency feedwater storage tanks are provided in the SBs, which are lined with stainless steel to prevent leakage. Cable, pipe, and duct shafts are located within the SBs for routing distribution systems between the various elevations of the buildings. These shafts are constructed of reinforced concrete and steel. The main control room (MCR) is located [
]

Physical separation of the three SB structures and additional hardening of the buildings 2 and 3 structure protects against damage to multiple divisions in the case of external events (e.g., hurricane and tornado missiles, aircraft hazard or blast loadings). SBs 2 and 3 are hardened by providing a dual roof and exterior walls, thickening the roof slab, and decoupling interior walls and slabs from the exterior walls and roof. The combined structure for buildings 2 and 3 extends approximately 92 feet out from the RSB wall by 180 feet long by 140 feet high. SB 1 has overall dimensions of approximately 87 feet out from the RSB wall by 100 feet long by 115 feet high. SB 4 has dimensions of approximately 87 feet out from the RSB wall by 100 feet long by 150 feet high. The NI Common Basemat Structure foundation basemat supports the SBs.

The main steam (MS) and feedwater valve ~~stations~~rooms are comprised of reinforced concrete compartments located within the SBs. Divisions 1 and 2 of the valve ~~stations~~rooms are located in SB 1, while Divisions 3 and 4 of the valve ~~stations~~rooms are located in SB 4. This arrangement results in a two-by-two redundancy. The physical separation of the valve ~~stations~~rooms results in at least two valve ~~stations~~rooms remaining unaffected in the case of external events (e.g., aircraft hazard). The reinforced concrete walls protect the individual valve ~~stations~~rooms against internal hazards.

Figure 3.8-53—Safeguard Building 1 Plan Elevation -31 Feet, Figure 3.8-54—Safeguard Building 1 Plan Elevation -16 Feet, Figure 3.8-55—Safeguard Building 1 Plan Elevation 0 Feet, Figure 3.8-56—Safeguard Building 1 Plan Elevation +15 Feet, Figure 3.8-57—Safeguard Building 1 Plan Elevation +27 Feet, Figure 3.8-58—Safeguard Building 1 Plan Elevation +39 Feet, Figure 3.8-59—Safeguard Building 1 Plan Elevation +55 Feet, Figure 3.8-60—Safeguard Building 1 Plan Elevation +69 Feet, Figure 3.8-61—Safeguard Building 1 Plan Elevation +81 Feet, Figure 3.8-62—Safeguard Building 1 Plan Elevation +96 Feet, and Figure 3.8-63—Safeguard Building 1 Section A-A show the arrangements of SB 1.

Figure 3.8-64—Safeguard Buildings 2 and 3 Plan Elevation -31 Feet, Figure 3.8-65—Safeguard Buildings 2 and 3 Plan Elevation -16 Feet, Figure 3.8-66—Safeguard Buildings 2 and 3 Plan Elevation 0 Feet, Figure 3.8-67—Safeguard Buildings 2 and 3 Plan Elevation +15 Feet, Figure 3.8-68—Safeguard Buildings 2 and 3 Plan Elevation

Figure 3.8-89—Emergency Power Generating Buildings Plan Elevation 0'-0", Figure 3.8-90—Emergency Power Generating Buildings Plan Elevation 33'-4", Figure 3.8-91—Emergency Power Generating Buildings Plan Elevation 51'-6", Figure 3.8-92—Emergency Power Generating Buildings Plan Elevation 68'-0", Figure 3.8-93—Emergency Power Generating Buildings Section A-A, and Figure 3.8-94—Emergency Power Generating Buildings Section B-B provides the elevation and section views of the EPGBs.

3.8.4.1.5 Essential Service Water Buildings

The ESWBs house the ESWCTs and the ESWPBs. The function of the ESWBs is to house equipment and cooling water associated with the essential service water system (ESWS). This system provides a source of cooling water to the component cooling water system (CCWS) heat exchangers, the Emergency Power Generator heat exchangers, and Essential Service Water HVAC system to support the safe operation and orderly shutdown of the plant, during normal operation or under accident conditions. As depicted in Figure 3B-1 each of the four structures is located in the vicinity of the NI Common Basemat Structure, but ESWBs 1 and 2 are physically separated from ESWBs 3 and 4 by the NI Common Basemat Structure to provide sufficient protection against external events (e.g., aircraft hazard).

Each ESWB is a reinforced concrete, shear wall structure approximately 164 feet by 108 feet wide by 118 feet high (i.e., from the bottom of the basemat to elevation 96 feet). Each structure is embedded 21 feet below grade. The primary portion of the structure is approximately 128 feet long by 108 feet wide, and houses two cooling towers, each with a water storage basin. On the side of the cooling towers facing the containment building, a structurally integrated pump house structure is located, enclosing primarily pumps and electrical equipment. The ESWPB is approximately 35 feet by 64 feet, with a roof at elevation 63 feet.

Exterior walls and slabs are sized for protection against external hazards, including tornado and hurricane-generated missiles and postulated blast loads. Two compartments are provided for air draft between elevation 14 feet and 43 feet, 6 inches.

Figure 3.8-95—Essential Service Water Building Plan Elevation 0'-0", Figure 3.8-96—Essential Service Water Building Plan Elevation 14'-0", Figure 3.8-97—Essential Service Water Building Plan Elevation 47'-0", Figure 3.8-98—Essential Service Water Building Plan Elevation 63'-0", Figure 3.8-99—Essential Service Water Building Plan Elevation 80'-0", Figure 3.8-100—Essential Service Water Building Roof Plan Elevation 96'-0", Figure 3.8-101—Essential Service Water Building Section A-A, and Figure 3.8-102—Essential Service Water Building Section B-B provides the elevation and section views of the ESWBs.

3.8.4.1.6 Distribution System Supports

Structural steel supports are provided for Seismic Category I distribution systems as part of other Seismic Category I structures. These include pipe supports, equipment supports, cable tray and conduit supports, HVAC duct supports, and other component supports. Distribution system supports are primarily constructed of steel shapes and tubing, which are anchored to other Seismic Category I concrete structures using embedded steel plates, cast-in-place anchor bolts, or drilled-in concrete anchors.

3.8.4.1.7 Platforms and Miscellaneous Structures

Platforms and miscellaneous structures (e.g., ladders, guard rails, stairs) are provided for access and maintenance to plant equipment and components housed in other Seismic Category I structures. These items are primarily constructed of steel beams, angles, channels, tubing, and grating. Platforms and miscellaneous structures are Seismic Category I, Seismic Category II, or Conventional Seismic depending on their safety function and potential interaction of the items with Seismic Category I SSC.

3.8.4.1.8 Buried Conduit and Duct Banks

The design of buried conduit and duct banks is site-specific. The design criteria for safety-related buried conduit and duct banks are provided below and in Section 3.8.4.4:

Safety-related conduit located outside of the building envelope is installed Seismic Category I and buried individually, as multiple conduits or in assemblies known as duct banks. [[Buried conduits are steel while conduits in encased duct banks may be poly-vinyl-chloride (PVC) or steel. Duct banks may be directly buried in the soil; encased in lean concrete, concrete, or reinforced concrete. Concrete or reinforced concrete encased duct banks will be used in heavy haul zones, under roadway crossings, or where seismic effects dictate the requirement. Encasement in lean concrete may be used in areas not subject to trenching or passage of heavy haul equipment, or where seismic effects on the conduit are not significant.]] Duct bank depth and encasement methods will also consider effects from external hazards (e.g. hurricane and tornado missiles).

The analysis of duct banks considers the type of loading imposed on the duct bank (seismic wave passage load, static surcharge, buoyancy, settlement, hurricane and tornado missiles), soil properties, the geometry of the duct bank (curved versus straight), and boundary conditions imposed on the ends of the duct bank. Reinforced concrete encasement for duct banks used in heavy haul routes or road crossings are evaluated for postulated loadings and provisions defined in Section 3.8.4.4.

A COL applicant that references the U.S. EPR design certification will provide a description of Seismic Category I buried conduit and duct banks.

- Soil loads and lateral earth pressure (H)—Soil loads and lateral earth pressure are loads that result from soil bearing pressures applied to buried exterior walls and structures up to the finished grade elevation of the surrounding soil. Refer to Section 2.5.4.2 for the soil parameters used to determine soil loads and lateral earth pressure. Normal soil loads consider saturated soil up to a groundwater elevation of -3.3 feet relative to the site finished grade.

- Construction loads—Construction loads are those loads to which the structure may be subjected during construction of the plant. Construction loads will be applied to evaluate partially-completed structures, temporary structures, and their respective individual members. Design load requirements during construction for buildings and other structures will be developed in accordance with Standard SEI/ASCE 37-02, "Design Loads on Structures During Construction." The magnitude and location of construction loads will be applied to generate the maximum load effects of dead, live, construction, environmental, and lateral earth pressure loads. Consideration will be given to the loads and load effects of construction methods, equipment operation, and sequence of construction.

Severe Environmental Loads

Severe environmental loads are those loads that could be encountered infrequently during the plant life (GDC 2). This load category includes:

- Wind loads (W)—Wind loads are those loads resulting from wind pressure acting on external surfaces of structures due to normal design wind speeds. See Section 3.3.1 for wind parameters and methods used to determine wind loads. Wind loads in this category do not include hurricane and tornado wind forces.

- Operating basis earthquake (OBE)—There are no OBE loads applicable to the design of other Seismic Category I structures, since an OBE level of one-third the SSE has been selected. See Section 3.7 for a description of the OBE.

Extreme Environmental Loads

Extreme environmental loads are those loads that are credible but are highly improbable (GDC 2). This load category includes:

- Safe shutdown earthquake (E')—SSE loads are those loads generated by an earthquake with a peak horizontal ground acceleration of 0.30 g. Seismic loads in the vertical direction and two orthogonal horizontal directions are considered to act simultaneously. Section 3.7 provides a description of how SSE loads are determined and combined. SSE loads are considered due to applied inertia loads, including dead loads, live loads, hydrodynamic loads (i.e., water in storage pools and tanks), and soil loads, including combination of these loads using the square root of the sum of the squares (SRSS) method.

  The SSE component of soil loads is determined using densities for saturated soil to account for the weight of the soil plus the weight of either normal or flood water levels. This includes using load cases for normal groundwater level at 3.3 feet below plant grade, and for flood water level at 1.0 foot below plant grade.

Earthquake-induced soil pressures are developed in accordance with Section 3.5.3 of ASCE 4-98.

- Tornado and Hurricane loads (W_t)—Tornado and Hurricane loads are those loads on external surfaces of structures resulting from a design basis tornado and hurricane. See Section 3.3.2 for tornado and hurricane design parameters and methods used to determine tornado and hurricane loads. See Section 3.5 for design methods and parameters used to determine hurricane- or tornado-generated missile loads. Tornado or hurricane loads include:
  - Tornado or hurricane wind pressure (W_w).
  - Tornado differential pressure (W_p) = 0 for hurricane.
  - Hurricane- or Tornado-generated missiles (W_m).
- External flood loads—External flood loads are included with soil loads and lateral earth pressure loads (H) and with SSE loads (E') as previously described by considering saturated soil conditions.

Abnormal Loads

Abnormal loads are those loads generated by a postulated high-energy pipe break accident (i.e., loss of coolant accident (LOCA)) within a building or compartment (GDC 4). This event is classified as a design basis accident. Included in this category are: Internal Flooding loads (F_a), Pressure loads (P_a), Thermal loads (T_a), Accident pipe reaction loads (R_a), and Pipe break loads (R_r). The Pipe break load is subcategorized as: Pipe break reaction loads (R_{rr}), Pipe break jet impingement loads (R_{rj}), and Pipe Break Missile Impact loads (R_{rm}). These loadings include a dynamic load factor to account for the dynamic nature of the load, unless a time-history analysis is performed to justify otherwise. Abnormal loads include the following loads:

- Internal flood loads (F_a)—Loads resulting from internal flooding of other Seismic Category I structures during or following a postulated pipe system failure that presents the risk of common mode failures of safety-related equipment (e.g., failures of cooling water systems in SBs 1 through 4). Hydrostatic loads from the maximum possible water level are applied to affected walls, slabs, and the basemat foundation.
- Pressure load (P_a)—Pressure equivalent static load within or across a compartment or building generated by the postulated break and including a dynamic load factor to account for the dynamic nature of the load.
- Thermal load (T_a)—Thermal loads generated by the postulated break and including T_o.
- Accident pipe reactions (R_a)—Pipe reactions generated by the postulated break and including R_o.

- Pipe break loads (R_r)—Local equipment and piping loads generated following a postulated pipe break. Unless a time-history analysis is performed to justify otherwise, these loadings include a dynamic load factor to account for the dynamic nature of the load. The pipe break load (R_r) is considered to act as three separate components (R_{rr}, R_{rj}, R_{rm}), which are defined below. In determining the equivalent static load for R_{rr}, R_{rj}, and R_{rm}, elasto-plastic behavior may be assumed with ductility ratios, provided excessive deflections do not result in loss of function of any safety-related SSC.

  – Pipe break reaction loads (R_{rr})—R_{rr} is defined as the equivalent static load on the structure generated by the reaction of the high-energy pipe during the postulated break.

  – Pipe break jet impingement loads (R_{rj})—R_{rj} is defined as the jet impingement equivalent static load on the structure generated by the postulated break.

  – Pipe break missile impact loads (R_{rm})—R_{rm} is defined as the missile impact equivalent static load on the structure generated by or during the postulated break, such as pipe whipping.

Other Loads

Other loads refer to postulated events or conditions that are not included in the design basis (GDC 4). These loading conditions and effects are evaluated without regard to the bounding conditions under which SSC are required to perform design basis functions. This load category includes:

- Aircraft hazard (A)—Aircraft hazard refers to loads on a structure resulting from the impact of an aircraft. The evaluation of this loading condition is considered as part of the plant safeguards and security measures.

- Explosion pressure wave (B)—Explosion pressure wave refers to loads on a structure resulting from an explosion in the vicinity of the structure. The evaluation of this loading condition is considered as part of the plant safeguards and security measures.

- Missile loads other than ~~wind or~~hurricane- or tornado-generated missiles—The hurricane- and tornado-generated missile spectra presented in Table 3.5-1 is considered to bound other external missile loads for the U.S. EPR other Seismic Category I structures. Turbine missiles and conformance to RG 1.115 are addressed in Section 3.5. As described in Section 3.5.1.3, the impact of turbine missiles on other Seismic Category I structures is not considered safety significant based on the redundancy and the low probability of a turbine missile being generated. Other Seismic Category I concrete and steel structures are designed for internally generated missile loads as described in Section 3.5.

equipment supports, cable tray supports, conduit supports, HVAC duct supports, and other component supports) and to Seismic Category I platforms and miscellaneous steel structures located within other Seismic Category I buildings and structures.

3.8.4.4.1 General Procedures Applicable to Other Seismic Category I Structures

[*Other Seismic Category I concrete structural elements and members are designed in accordance with the requirements of ACI 349-2001 and its appendices*]* (GDC 1). Exceptions to code requirements specified in RG 1.142 are incorporated into the design and are accommodated in the loading combinations described in Section 3.8.4.3.2 for concrete structures.

[*The design of concrete walls, floors, and other structural elements for other Seismic Category I structures is performed using the strength-design methods described in ACI 349-2001. The ductility requirements of ACI 349-2001 are satisfied to provide a steel reinforcing failure mode and prevent concrete failure for design basis loadings.*

The design of anchors and embedments conforms to the requirements of ACI 349-06 (Appendix D with exception stated in Section 3.8.1.2.1)]* and RG 1.199 (with exception described in Section 3.8.1.4.10). [*The requirements of Appendix C of ACI 349-2001 are followed for impulsive and impactive loading conditions (e.g., loading combinations that include pipe break missile impact loads ~~or~~, hurricane- or tornado-generated missile impact loads).*

Other Seismic Category I steel members and assemblies are designed in accordance with ANSI/AISC N690-1994 (R2004, including Supplement 2) (GDC 1). Steel member design uses the allowable stress design methods of ANSI/AISC N690.

The design of bolted connections is in accordance with ANSI/AISC N690, Section Q1.16 and AISC 348-00/2000 RCSC, "Specification for Structural Joints Using ASTM A325 and A490 Bolts."]* Bolted connections are designed to be fully tensioned (e.g., slip critical) unless justified otherwise.

The design of welded connections is in accordance with AWS D1.1 or AWS D1.6.

[*The design of bolted connections in combination with welded connections is in accordance with Section Q.15.10 of ANSI/AISC N690.*]*

Loads and load combinations defined in Section 3.8.4.3 are used to determine strength requirements of members and elements of other Seismic Category I structures. Abnormal pipe break accident loads only apply to limited areas of structures located on the NI Common Basemat Structure. The following criteria apply for load combinations for concrete and steel other Seismic Category I structures:

- Where any load reduces the effects of other loads, the corresponding coefficient for that load is 0.9 if it can be demonstrated that the load occurs simultaneously with other loads.

- Where the structural effects of differential settlement, creep, or shrinkage may be significant, they are included with the dead load (D) as applicable.

- For load combinations in which a reduction of the maximum design live load (L) has the potential to produce higher member loads and stresses, multiple cases are considered where the live load (L) is varied between its maximum design value and zero.

- Roofs with a slope of less than 0.25 inches per foot are analyzed for adequate stiffness to preclude progressive deflection as water ponding is created from the snow load or from rainfall on the surface. The analysis considers the potential blockage of the primary drainage system of the area that is subject to ponding loads. The analysis uses the larger of the snowmelt depth or rain load.

- For load combinations including the loads P_a, T_a, R_a, R_{rr}, R_{rj}, or R_{rm}, the maximum values of these loads, including a dynamic load factor, are used unless a time-history analysis is performed to justify otherwise.

- For load combinations including loads R_{rr}, R_{rj}, R_{rm}, or W_m, these load combinations are first satisfied with these loads set to zero. However, when considering these concentrated loads, local section strength capacities may be exceeded under the effect of these concentrated loads, provided there is not a loss of intended function of the structural member or a loss of function of any safety-related SSC.

- Tornado and hurricane loads are applied to roofs and exterior walls of other Seismic Category I structures. If tornado and hurricane pressure boundaries are not established at the exterior walls, interior walls are designed as tornado and hurricane pressure boundaries.

- For load combinations that include a tornado and hurricane load (W_t), the tornado and hurricane load parameter combinations described in Section 3.3 are used.

Concrete and steel structural elements and members are designed for axial tension and compression forces, bending moments, torsion, and in-plane and out-of-plane shear forces for the controlling loading combinations that are determined from analysis. Concrete and steel members and elements remain elastic for loadings other than impact. Local yielding is permitted for localized areas subjected to hurricane- and tornado-generated missile loads, pipe break accident loadings, and beyond design basis loadings. The structural integrity of members and elements is maintained for the loading combinations described in Section 3.8.4.3.

[*A local analysis and design of concrete members will be performed for impactive and impulsive loads according to ACI 349, with exceptions noted in RG 1.142. A local* out-of-plane response. Stiffness of the composite beams is not required in the static analysis model as only in-plane stresses in the concrete slab are determined.

For the composite beams and floor slab at elevation 51 feet, 6 inches, the corresponding floor accelerations from the SASSI analysis output are applied to tributary floor areas and walls to obtain the seismic loads associated with the out-of-plane loads. Dead load, live load, equipment loads, and piping loads are combined with the seismic loads. The composite beams are analyzed outside of the FEM. [*Structural design of the composite beams is in accordance with the provisions of ANSI/AISC N690-1994 (R2004).*]*

The in-plane and out-of-plane results from the GT STRUDL equivalent static analysis are extracted and used to design reinforced concrete shear walls and slabs according to provisions of ACI 349-01. The evaluation of walls and slabs for external hazards (e.g., hurricane- or tornado generated missiles and blast loads) is also performed by local wall and slab analyses. Structural element reinforcement is designed to provide sufficient ductility.

Additional information on the seismic analysis approach for the EPGBs is contained in Section 3.7.2.

For the design of the EPGBs, some details for the composite beams and slabs at elevation 51 feet, 6 inches, particularly changes in beam sizes and floor openings, as well as certain aspects of mechanical design layout, are not reflected in the SASSI FEM used for SSI analyses. Inclusion of these details in the SASSI FEM are not expected to have any significant impact on the seismic forces used in the design of the EPGBs, but may impact the in-structure response spectra. Therefore, a subsequent analysis will be performed with these details in the FEM to confirm the seismic responses and in-structure response spectra presented in Section 3.7.2. The design of the EPGBs will conform to the structural acceptance criteria described in Section 3.8.4.5.

3.8.4.4.4 Essential Service Water Buildings

Reinforced concrete elements for the four ESWBs consist of slabs, beams, shear walls, and foundation basemat to transfer imposed loads to the supporting soil. Structural steel framing is used to support the missile barriers protecting the safety-related fans.

Similar to the EPGBs, the ESWBs are analyzed and designed using a 3D FEM representing the structure. The FEM is generated using the GT STRUDL computer code. The use of the model for both static and dynamic analyses, including extraction of results for design, is almost identical to the methods presented in Section 3.8.4.4.3. Similarly, the GT STRUDL model is used to provide an accurate representation of the structure for translation to an SSI model (SASSI 2000) for seismic analysis. As such, only model variations are addressed below.

In addition to structural dead loads, slab live loads, piping loads and equipment loads, the GT STRUDL FEM for the ESWBs includes the weight of non-structural fill, hydrostatic loads, hydrodynamic loads, and soil pressures (including surcharge pressures). The appropriate accelerations from the SSI analysis are applied to the tributary floor areas and walls to obtain the equivalent static seismic loads.

[*Dead load, live load, equipment loads, and piping loads are combined with the equivalent static seismic loads for structural design in accordance with the provisions of ACI 349-01, with supplemental guidance of RG 1.142, ACI 350-06, and ACI 350.3-06.*]* The evaluation of walls and slabs for external hazards (e.g., hurricane- or tornado- generated missiles) is performed by local analyses, including ductility evaluations. The elastic solution methodology of ASCE 4-98, Section 3.5.3.2 is used for the dynamic soil pressures associated with the 21 feet embedment of the ESWBs.

Seismic induced lateral soil pressure on below grade walls are evaluated considering the following cases:

- The seismic soil pressure as equal to the sum of the static earth pressure plus the dynamic earth pressure calculated in accordance with ASCE 4-98, Section 3.5.3.2.
- The seismic soil pressure as equal to the passive earth pressure.

Additional information on the seismic analysis approach for the ESWBs is contained in Section 3.7.2.

3.8.4.4.5 Buried Conduit and Duct Banks, and Buried Pipe and Pipe Ducts

The design of buried conduit and duct banks, and buried pipe and pipe ducts is site-specific. Buried Seismic Category I conduit, electrical duct banks, pipe, and pipe ducts will be analyzed and designed in accordance with the specific requirements of the systems. In addition, these items will be designed for the effects of soil overburden, surcharge, groundwater, flood, seismic soil interaction, and other effects of burial. [*Concrete components of buried items will be designed in accordance with ACI 349-2001, including the exceptions specified in RG 1.142. Steel components of buried items will be designed in accordance with ANSI/AISC N690-1994 (R2004), including Supplement 2.*]*

Static and long-term analyses of buried items will be based on soil properties under consolidated drained conditions of the soil. Buried items will be designed for soil loads corresponding to the weight of the overlying soil prism.

Live loads will be applied, such as those imposed by truck and rail traffic and by construction equipment and activities. Where buried items are vulnerable to highway or railway traffic loads, the potential for fatigue-induced failure will be evaluated. The basemat provides for anchorage of the RCB vertical post-tensioning tendons, and the portion of the basemat under the RCB/RSB is designed to accommodate loads from containment.

[*Loads and load combinations on Seismic Category I foundations are in accordance with ACI 349-01, RG 1.142, RG 1.199, and ANSI/AISC N690-1994, including Supplement 2 (2004) for steel structures (GDC 1, GDC 2, GDC 4 and GDC 5).*]* [*Loads and load combinations on the portion of the NI Common Basemat Structure foundation basemat that supports the RCB/RSB are in accordance with the ASME Code–2004 Edition, Section III, Division 2 and RG 1.136 (Exception: RG 1.136 endorses the 2001 Edition of the ASME Code with the 2003 addenda (including exceptions taken in RG 1.136). The U.S. EPR standard plant design is based on the 2004 Edition of the Code, inclusive of the exceptions taken in RG 1.136).*]*

The NI Common Basemat Structure is a monolithic concrete structure. However, various portions of the structure have different classifications (i.e., RCB, RB internal structures, and other Seismic Category I structures) and correspondingly different design requirements, as shown in Figure 3.8-118. In some instances, the load combinations identified in SRP Section 3.8.5 do not include certain independent loadings which should be considered to account for potential structure-to-structure effects (i.e., the effect on one structure resulting from loadings applied to a separate, but monolithically connected, structure). To account for potential structure-to-structure effects, the loading combinations from SRP Section 3.8.5 are adjusted by including the necessary additional independent loadings. All load combinations include an additional hydrostatic load (F) while all sliding and overturning load combinations include an additional buoyant force (F_b). The load factors for hydrostatic load (F) and buoyant force (F_b) are matched to that of the dead load (D) for each loading combination.

In addition to the load combinations specified above, the following load combinations are applied for Seismic Category I foundations to consider sliding and overturning due to earthquakes, winds, hurricanes, and tornados and against flotation due to floods:

$D + H + W + F + F_b$

$D + H + E' + F + F_b$

$D + H + W_t + F + F_b$

$D + F_b + F$

where:

F_b = the buoyant force of the design basis flood at maximum site water level. Refer to Section 3.8.4.3.1 for definitions of the other load parameters.

The U.S. EPR Seismic Category I foundations are also designed for the effects of short term and long term settlements. The settlement analysis is described in Section 3.8.5.4. Section 2.5 and Section 3.8.5.5 provides the settlement limits considered for the U.S. EPR.

There are no OBE loads applicable to the design of Seismic Category I foundations, since an OBE level of one-third the SSE has been selected. See Section 3.7 for a description of the OBE.

3.8.5.4 Design and Analysis Procedures

Design and analysis procedures are similar for the various Seismic Category I foundations but vary somewhat from structure to structure. The general analysis and design procedures applicable to Seismic Category I foundations are provided in the following sections. Procedures specific to the following Seismic Category I foundations also are described.

- NI Common Basemat Structure foundation basemat.
- EPGBs foundation basemats.
- ESWBs foundation basemats.

3.8.5.4.1 General Procedures Applicable to Seismic Category I Foundations

Concrete foundation basemats for Seismic Category I structures are analyzed as flat slabs on elastic supports to represent the underlying soil. Loads are applied to the foundation basemats by the interfacing reinforced concrete walls and structural steel columns that comprise the building structures being supported, as well as by equipment supported directly on the foundations. Intersecting concrete walls also serve to stiffen the foundation basemat slabs to increase resistance to bending moments resulting from soil pressures under the slabs. Foundations are analyzed for the various factored loads and load combinations identified in Section 3.8.5.3.

Seismic Category I foundation basemat structures transfer vertical loads from the buildings to the subgrade by direct bearing of the basemats on the subgrade. Horizontal shears, such as those produced by wind, hurricanes, tornados, and earthquakes are transferred to the subgrade by friction along the bottom of the foundation basemat, shear key, or by passive earth pressure.

The stability evaluations for the NI, EPGB, and ESWB are based on SSI analysis results, as described in Section 3.7.2.3. The coefficient of passive soil pressure corresponding to the sidewall movements into the soil are estimated from the SSI analysis and are used to calculate the passive soil pressure resisting sidewall movement.

Passive soil pressure capacities are based on constitutive models, typically used for granular media, such as Drucker-Prager or Coulomb-Mohr. For soil sites, a granular backfill material is used against side walls and underneath the structures, if needed. Backfill shall be installed to meet 95 percent of the Modified Proctor density (ASTM

3.8.5.5.2, and 3.8.5.5.3. Accordingly, Seismic Category I foundations are sized and reinforced to accommodate these bearing pressure values.

The following criteria apply for load combinations for concrete and steel Seismic Category I foundations:

- Where any load reduces the effects of other loads, the corresponding coefficient for that load is 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with other loads.
- For load combinations in which a reduction of the maximum design live load (L) has the potential to produce higher member loads and stresses, multiple cases are considered where the live load (L) is varied between its maximum design value and zero.
- For load combinations that include a tornado or hurricane load (W_t), the tornado or hurricane load parameter combinations described in Section 3.3 are used.

Loads and load combinations defined in Section 3.8.5.3 are used to determine strength requirements of members and elements of Seismic Category I foundations. Concrete and steel structural elements and members are designed for axial tension and compression forces, bending moments, torsion, and in-plane and out-of-plane shear forces for the controlling loading combinations that are determined from analysis. Concrete and steel members and elements remain elastic for loadings other than impact. Local yielding is permitted for localized areas subjected to hurricane- or tornado-generated missile loads, pipe break accident loadings, and beyond design basis loadings. The structural integrity of members and elements is maintained for the loading combinations described in Section 3.8.5.3.

For the loading combinations identified in Section 3.8.5.3, the minimum factors of safety required to prevent sliding and overturning are specified in Table 3.8-11—Minimum Required Factors of Safety Against Overturning, Sliding, and Flotation for Foundations.

Normal lateral earth pressure loads consider saturated soil up to a groundwater elevation of -3.3 feet relative to site finished grade. Lateral soil loads due to external floods consider saturated soil up to elevation -1.0 feet relative to site finished grade. Seismic loads from all three components of the earthquake motion are combined using the SRSS method. The SSE components of soil loads are determined using densities for saturated soil to account for the weight of the soil plus the weight of either normal or flood water levels. Earthquake-induced lateral soil pressures are obtained from SSI analyses for NI common basemat structures, EPGB, and ESWB. The design of embedded elements, such as embedded walls on basemats, assumes that the lateral pressure due to the SSE is in phase with the inertial loads. In cases where passive pressure is assumed to act on embedded structures in the stability check against sliding, the walls of the structure are evaluated to withstand such earth pressure.

Analysis

The ANSYS basemat model is loaded statically by accelerating the lumped and distributed masses described in Section 3.7.2.3.1.2 before a nonlinear time-history analysis is performed. The initial conditions (dead load, 25% live load, 75% precipitation load, hydrostatic forces and at-rest earth pressures) to the basemat foundation model (nonlinear) are input by performing multiple static analysis load steps prior to the start of the dynamic load. Static load steps are performed in a transient analysis by turning off the transient time integration effects. The static analysis time-steps are performed at solution times less than 0.005sec. The transient itself is started by turning on the time integration effects at time = 0.005sec to the end of the acceleration time-history input.

The seismic input motions are in-column ground motions obtained from SHAKE91 analysis runs at the bottom of the NI Common Basemat foundation level in the three translational directions derived using the NEI approach in Section 2.5.2.6.

The seismic time-history analysis starts from time = 0.005 sec. Thus, effects of the seismic loads are obtained by subtracting the results at time-history data points with the static analysis baseline results. The maximum seismic loads are obtained by determining the maximum/minimum design load values for basemat and tendon gallery for each of the elements/nodes over all time points of the transient analysis.

In addition to the seismic load, the basemat foundation model is analyzed (with static soil springs) for various static load cases: normal loads (e.g., dead, live, soil/lateral earth pressure, thermal load, pipe reaction, post-tension loads, relief valve loads), construction loads, test loads for reactor containment building, severe environmental loads (e.g., wind), extreme environmental loads (e.g., tornado and hurricane), abnormal loads (e.g., internal flood, buoyant pressure, accident pressure).

~~SSI analysis is performed using SASSI and a linear elastic 3D FEM model. The resulting soil loadings on the embedded walls and the tendon gallery are used as the basis for the design of these structural elements. The SSI analysis does not capture the nonlinear response of sliding and uplift. Any increases in loading due to sliding and uplift from the 3D basemat FEM is added to the SSI results. The analytical methodology is described in Section 3.7.2.3.1.4.~~

Design Considerations

~~The NI stability analysis using seismic reaction forces from the SSI model addressed in Section 3.7.2 considers the soil cases in Table 3.7.1-6.~~

Section 3.8.1, Section 3.8.3, and Section 3.8.4 provide descriptions of interfacing structures that induce loads on the NI Common Basemat Structure foundation basemat. The figures in those sections illustrate the concrete shear walls and columns

Pressure

Design pressure is described in Section 3.3 of Reference 2 and applies to ASME Code Class 1, 2, and 3 components and piping. The criteria for incorporating the effects of both internal and external pressures for components are described in the ASME Code, Section III, Articles NB-3000, NC-3000, and ND-3000.

Deadweight

Deadweight analyses consider the weight of the component, piping, or structure being analyzed and the additional weight of contained fluid, external insulation, and other appurtenances. For piping and components, the deadweight present during hydrostatic test loadings is also considered where such loadings exceed the normal operational deadweights. Static and dynamic heads of liquid are also included in the deadweight analyses of components. Deadweight loads are further described in Sections 3.3.1.2 and 6.3.1 of Reference 2.

Thermal Expansion

The effects of restrained thermal expansion and contraction on piping and supports are described in Section 3.3.1.3 and Section 6.3.2 of Reference 2.

Seismic

Analyses of seismic inertial loads and anchor movements on piping systems and the RCS are described in Sections 3, 4, and 6 of Reference 2 and Appendix 3C, respectively. In addition to the inertia and anchor movement stress effects due to a seismic event, the fatigue effects of such cyclic events are considered in the design of Class 1 components and piping. The number of safe shutdown earthquake (SSE) stress cycles included in the fatigue analysis is identified in FSAR Section 3.7.3 and in Section 3.4.1 of Reference 2.

System Operating Transients

Analyses of system operating transients, including fluid transient loadings, on piping systems and the RCS are discussed in Sections 3.3.1.5 and 6.3.4 of Reference 2 and Appendix 3C, respectively. Thermal and pressure transients are described in Section 3.3.1.8 of Reference 2. Section 3.3.1.5 of Reference 2 also describes water and steam hammer loads. The analysis of these transients results in force time histories for application in the piping analyses.

Wind, Hurricane, and Tornado

Wind, hurricane, and tornado loads are discussed in Sections 3.3.1.6, 6.3.5, and 6.3.6 of Reference 2. As noted in ANP-10264NP-A, should a COL applicant that references the U.S. EPR design certification find it necessary to route Class 1, 2, and 3 piping not included in the U.S. EPR design certification so that it is exposed to wind, hurricane, and tornadoes, the design must withstand the plant design-basis loads for this event.

Pipe Break

Loads due to pipe breaks are described in Section 3.3.1.7 of Reference 2. Additionally, the leak-before-break methodology is used to eliminate the dynamic effects of pipe rupture for the main coolant loop, pressurizer surge line, and portions of the main steam line piping (see Section 3.6.3).

Pipe break load design condition and service level evaluations are described in Sections 6.3.7, 6.3.8, and 6.3.9 of Reference 2. Design basis pipe breaks (DBPB) are categorized as Level C. Main steam and main feedwater pipe breaks and LOCA are categorized as Level D.

SRP 3.9.3, Table II defines a DBPB as:

> "Those postulated pipe breaks other than a LOCA or MS/FWPB. This includes postulated pipe breaks in Class 1 branch lines that result in the loss of reactor coolant at a rate less than or equal to the capability of the reactor coolant makeup system. This condition includes loads from the postulated pipe breaks, itself, and also any associated system transients or dynamic effects resulting from the postulated pipe break."

For the U.S. EPR, make-up flow can compensate for the loss of coolant from a break with a diameter of less than one inch. Postulated breaks in one-inch nominal diameter piping and smaller piping, in accordance with the guidance in BTP 3-4, do not require the analysis of the dynamic mechanical loadings from the ruptured pipe on components, component supports or core support structures and, therefore, are not included in Table 3.9.3-1, which provides the loading combinations for mechanical loads. See Section 6.3.9 of Reference 7 for a definition of LOCA as it applies to load combinations for the U.S. EPR design.

Friction

Friction loads are described in Section 6.10 of Reference 2.

Minimum Pipe Support Design Loads

Minimum design loads are described in Section 6.3.11 of Reference 2. Normal condition allowable stresses are applicable to the stresses resulting from the described applied loads. Use of this criterion does not eliminate the requirement to analyze supports for applicable service conditions.

Table 3.9.3-2—Load Combinations and Acceptance Criteria for ASME Class 2 and 3 Components

Loading Condition	Service Levels	Loads[3]	Stress Criteria[2,4]
Design/Normal	-/A	Sustained Loads: Pressure, Weight, Other Mechanical Loads	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Upset	B	Occasional Loads: Pressure, Weight, Thermal Effects, Dynamic Fluid Loads[1], Wind[5]	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Emergency	C	Occasional Loads: Pressure, Weight, Thermal Effects, Dynamic Fluid Loads[1], Hurricane, and Tornado[5]	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Faulted	D	Occasional Loads: Pressure, Weight, Thermal Effects, DFL[1], SSE Inertia, Pipe Break	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves

Notes:

1. Dynamic fluid loads (DFL) are occasional loads such as safety and relief valve thrust, steam hammer, water hammer, or other loads associated with plant upset or faulted condition as applicable.
2. ASME Code Section III.
3. Dynamic loads are combined by the SRSS method.
4. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," Paragraph 9, 'Elimination of Operating Basis Earthquake,' Nuclear Regulatory Commission, July 21, 1993.
5. Wind, hurricane, and tornado loads are not combined with earthquake loading.

Table 3.9.3-4—Load Combinations and Acceptance Criteria for ASME Class 1, 2, and 3 Component Supports

Loading Condition	Service Limits	Loads[3]	Stress Criteria[2,4]
Design/Normal	-/A	Loads: Weight, Thermal Effects, Other Mechanical Loads	Table NF-3131(a)-1
Upset	B	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], Wind[5]	Table NF-3131(a)-1
Emergency	C	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], Hurricane, and Tornado[5]	Table NF-3131(a)-1
Faulted	D	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], SSE Inertia, Pipe Break	Table NF-3131(a)-1
Testing	N/A	Loads: Weight	Table NF-3131(a)-1

Notes:

1. DFL are occasional loads such as safety and relief valve thrust, steam hammer, water hammer, or other loads associated with plant upset or faulted condition as applicable.

2. Table NF-3131(a)-1 of the ASME Code, Section III, Subsection NF provides a cross-reference to various sections of NF for stress allowables for specific types of component supports.

3. Dynamic loads are combined by the SRSS method.

4. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," Paragraph 9, 'Elimination of Operating Basis Earthquake,' Nuclear Regulatory Commission, July 21, 1993.

5. Wind, hurricane, and tornado loads are not combined with earthquake loading.

Next File

In addition to the CRDS, reactivity control systems that operate under shutdown conditions, normal operating conditions, transients, or postulated accident conditions include:

- Chemical and volume control system (CVCS).
- Extra borating system (EBS).
- SIS.

4.6.1 Information for Control Rod Drive System

The U.S. EPR contains 89 electromagnetic jack type CRDMs, each consisting of a drive rod, pressure housing, latch unit, and coil housing assembly. The CRDMs use natural air circulation, convection cooling; therefore a separate, dedicated liquid or forced air cooling system is not required. Natural convection cooling maintains the temperature of the CRDMs below design operating temperature. CRDM equipment is designed and qualified to operate in the reactor vessel cavity environment. Details of these CRDM components and how the components operate are provided in Section 3.9.4, and a diagram of the CRDM assembly is shown in Figure 3.9.4-1. An overview of the CRDM penetrations into the reactor pressure vessel is provided in Figure 3.9.5-1, and the layout of RCCA control and shutdown banks within the core is provided in Figure 4.3-34. The RCCAs are described in Section 4.2. The instrumentation and control (I&C) systems providing rod control are described in Section 7.7, which includes the CRDCS and RCSL systems.

The CRDMs are mounted on top of the reactor pressure vessel head and are protected from potential hurricane and tornado-generated missile damage by being housed in a Seismic Category 1 structure (i.e., containment). The CRDMs are protected from internally generated missiles by the concrete secondary shield wall and by reinforced concrete missile shield slabs mounted above the reactor vessel. The CRDMs are seismically restrained by the reactor pressure vessel closure head equipment as addressed in Section 5.4.14.

The I&C systems associated with RCCA control count CRDM movement steps to provide a digital measurement of RCCA position. The CRDMs are also equipped with position indicator coils that provide analog RCCA position measurements. As such, the RCCA position is measured over the height of the core by two diverse methods:

- The digital measurement is non-safety related.
- The analog measurement, using position indicator coils, is safety related.

Additionally, a safety related rod position limit sensor provides input to the PS when the RCCA is at the bottom position and a non-safety related upper position limit sensor provides indication when the RCCA is at the top position.

6.2.1.1 Containment Structure

6.2.1.1.1 Design Bases

The containment's structures, systems, and components (SSC) that are important to safety are designed to withstand the environmental and dynamic effects associated with both normal plant operation, including maintenance and testing, and postulated accidents. The environmental effects include the temperatures, pressures, and fluids encountered during normal and accident conditions. The dynamic effects include those arising from in-plant equipment failures or accidents, including missiles, pipe whipping, and fluid discharge, as well as those resulting from events and conditions outside the containment (e.g., hurricanes, tornadoes, earthquake, or aircraft impact).

The containment and its associated systems are designed to be a leaktight barrier against the release of radioactivity to the environment and are designed to remain functional during a DBA. By meeting these performance requirements, including requirements for access openings and penetrations of the structure and its internal compartments, the containment is designed to accommodate the calculated pressures and temperatures resulting from a LOCA without exceeding its designed leakage limits. It can do so with margin for extra energy sources and degraded engineered safety features (ESF), and using conservative calculational methods.

The radiological consequences of the DBA are presented in Section 15.0.3. The containment, containment systems, and ESF act to limit the release of radioactive material subsequent to a DBA, so that the release does not exceed the limits specified in 10 CFR 52.47(a)(2)(iv).

Containment design calculations assume the following for an RCS pipe rupture:

- The postulated rupture occurs concurrently with the worst single active failure.
- The systems used to mitigate the consequences of a postulated pipe rupture are protected against dynamic effects, including the effects of missiles, pipe whipping, and fluid discharge, that may result from equipment failures and from events and conditions outside the nuclear power unit subject to design loadings from a safe shutdown earthquake.
- The offsite electrical power system is evaluated to provide the most limiting condition for each postulated break, for example, a loss of offsite power (LOOP) or no LOOP.
- The building doors that are non-safety are conservatively not allowed to open during postulated pipe ruptures.
- Discharge coefficients (Cd) and backpressure values are assumed, so as to produce the most limiting condition for each postulated break.

Compliance with Clause 4.f is described in Section 7.2.2 and Section 7.3.2.

7.1.3.6.6 Design Basis: Range of Operating Conditions (Clause 4.g)

The safety-related systems meet the requirements of Clause 4.g of IEEE Std 603-1998 (Reference 1).

The safety-related systems are qualified in accordance with the program described in Section 3.11. This qualification includes:

- Environmental effects (e.g., temperature and humidity).
- Seismic effects.
- EMI/RFI effects.

The safety-related systems are powered by Class 1E power supplies, including the EUPS and Class 1E power supply system (EPSS). The safety systems are designed to remain functional within the range of voltage and frequency provided. The EPSS and EUPS are described in Section 8.3.

7.1.3.6.7 Design Basis: Protection Against Natural Phenomena and Unusual Events (Clause 4.h)

The safety-related systems meet the requirements of Clause 4.h of IEEE Std 603-1998 (Reference 1).

The safety-related systems are designed to perform their required functions in the presence of natural phenomena and unusual events, which include seismic events, hurricanes, tornadoes, and internal flooding. Refer to Chapter 3 for further information on these events. This is accomplished through the principles of independence described in Section 7.1.1 and equipment qualification described in Section 3.11.

7.1.3.6.8 Design Basis: Reliability Methods (Clause 4.i)

The safety-related systems meet the requirements of Clause 4.i of IEEE Std 603-1998 (Reference 1).

Two methods are used to evaluate the reliability of the safety-related systems. A FMEA is performed for the PS, and provides a qualitative means of evaluating the reliability of the system.

The probabilistic risk assessment (PRA) is used as a quantitative means for performing reliability analysis. The PRA is described in Chapter 19.

The physical separation that is provided among the MSUs, NATs and EATs power feeds and control circuits includes these:

- A separate takeoff structure is provided for each preferred power circuit overhead line from the switchyard to the EAT to reduce the likelihood of simultaneous failure of both circuits.
- Power cables between the EATs and 6.9 kV Class 1E switchgear buses are physically independent (to the extent practical) to minimize the likelihood of simultaneous failure.
- Control power to each EAT is separated from each other and the PPS power circuits.
- Each phase of the main generator output is routed to the MSU in an isolated phase bus.
- MSUs and auxiliary transformers are separated from plant buildings in accordance with the guidance provided by RG 1.189.
- EATs are separated from each other and the NATs and MSUs by at least 50 feet or by a one hour rated fire barrier.

The station auxiliary transformer distribution to the EPSS and NPSS is illustrated in Figure 8.3-2—Emergency Power Supply System Single Line Drawing and Figure 8.3-3—Normal Power Supply System Single Line Drawing. Transformer ratings are included in Table 8.3-1—Onsite AC Power System Component Data Nominal Values.

[[The MSU and auxiliary transformers have a deluge fire protection system that provides a distribution spray pattern over the respective transformer for fire suppression. The deluge system is automatically actuated by a heat-sensing device located around the perimeter of the respective transformer or manually activated from the transformer valve station. Additionally, each transformer has an oil retention pit.]]

8.2.2 Analysis

Offsite power meets the acceptance criteria established in 10 CFR 50, Appendix A. Additionally, conformance with the regulations and the recommendations of RGs, BTPs, as well as industry codes and standards adopted by the RGs, is described in Section 8.2.2.1 through Section 8.2.2.7.

8.2.2.1 Compliance with GDC 2

Offsite power system components are designed in accordance with GDC 2 to withstand effects of natural phenomena (excluding seismic, hurricane, tornado, and flood) without loss of capability to perform their intended functions within the

- Three Mile Island (TMI) action plan requirements of NUREG-0737 (Reference 14).

Conformance with recommendations of RGs as well as IEEE Standards adopted by the RGs is described in this section.

8.3.1.2.1 Compliance with GDC 2

The onsite AC distribution system Class 1E components are located in Seismic Category I structures capable to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without losing their capability to perform safety-related functions. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in Chapter 2. The U.S. EPR design criteria for wind, hurricane, tornado, flood, and earthquakes are described in Section 3.3, Section 3.4, and Section 3.7, respectively.

8.3.1.2.2 Compliance with GDC 4

Class 1E onsite AC distribution system components are located in Seismic Category I structures, in rooms constructed in such a manner that any internal hazard only affects the respective division. There are no high energy lines routed through the dedicated electrical rooms containing EPSS equipment such as switchgear, LCs, MCCs and distribution transformers. These rooms are also provided conditioned air that maintains ambient environmental conditions within equipment qualifications during normal operations and DBEs. Details of the design and construction of safety-related structures are included in Chapter 3.

The environmental qualification program for electrical equipment provides reasonable assurance that equipment remains operable during and following exposure to harsh environmental conditions as a result of a design basis event. An evaluation of equipment locations will be performed to determine if any electrical equipment will have to be qualified for submerged operation. Environmental qualification is described in Section 3.11. Safety-related electrical equipment located in an environmental harsh or radiation harsh environment that require qualification are listed in Section 3.11, Table 3.11-1—List of Environmentally Qualified Electrical/I&C Equipment.

8.3.1.2.3 Compliance with GDC 5

GDC 5 is satisfied with the U.S. EPR designed as a single-unit station.

8.3.1.2.4 Compliance with GDC 17

Compliance with GDC 17 is accomplished through the design of the onsite power AC distribution system capacity, capability, independence, redundancy, and meeting the application of the single failure criteria.

conformance with recommendations of RGs as well as IEEE Standards adopted by the RGs is described in this section.

8.3.2.2.1 Compliance with GDC 2

The EUPS components are located in Seismic Category I structures to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without losing their capability to perform required safety-related functions. The nature and magnitude of the natural phenomena considered in the U.S. EPR design are described in Chapter 2. The U.S. EPR design criteria for wind, hurricane, tornado, flood, and earthquakes are described in Section 3.3, Section 3.4, and Section 3.7, respectively.

8.3.2.2.2 Compliance with GDC 4

EUPS system components are located in Seismic Category I structures, in rooms constructed in such a manner that any internal hazard only affects the respective division. Details of the design and construction of safety-related structures are included in Chapter 3.

There are no high-energy lines routed through the dedicated electrical rooms containing batteries, battery chargers, inverters, MCCs, panelboards or switchboards. These rooms are also provided with conditioned air that maintains ambient environmental conditions within equipment qualifications during normal operations, DBEs and SBO. Details of the design and construction of safety-related structures are included in Chapter 3.

8.3.2.2.3 Compliance with GDC 5

GDC 5 is satisfied with the U.S. EPR designed as a single-unit station.

8.3.2.2.4 Compliance with GDC 17

Compliance with GDC 17 is accomplished through the design of the onsite power DC distribution system capacity, capability, independence, redundancy, and single failure criteria.

There are four independent and redundant EUPS systems. Each EUPS system battery and battery charger provides power to the DC switchboard which provides power to the 250 Vdc loads and inverter of each division. The inverter powers the 480 Vac loads that require uninterruptible power and AC/DC converters that are operated in parallel to supply DC power to redundant safety-related loads. These components have the required independence, redundancy, and testability to perform their safety-related functions in the presence of a single failure.

the COL applicant. The site-specific UHS systems are shown in Figure 9.2.5-2—[[Conceptual Site-Specific UHS Systems]].

9.2.5.3 Component Description

9.2.5.3.1 Mechanical Draft Cooling Towers

The cooling towers are rectangular mechanical-induced draft-type towers. Each tower consists of two cells in a back-to-back arrangement. The two cells of the cooling tower in a particular division share a single cooling tower basin and each cell is capable of transferring fifty percent of the design basis heat loads for one division from the ESWS to the environment under worst-case ambient conditions. The division four cooling tower shares use with the dedicated ESW train and can transfer severe accident (SA) heat loads to the environment under worst-case ambient conditions.

The Division 4 cooling tower fans can be supplied by a standby EDG or a station blackout diesel generator (SBODG) that is provided as an alternate AC power source.

The cooling tower fill design and arrangement maximize contact time between water droplets and air inside the tower. The tower fill spacing is chosen to minimize the buildup of biofilm and provide for ease of cleaning, maintenance, and inspection.

UHS cooling tower fill is constructed of ceramic tile, supported on reinforced concrete beams. Spray piping and nozzles are fabricated of corrosion resistant materials (e.g., stainless steel, bronze). UHS cooling tower internals are seismically designed and supported to withstand a safe shutdown earthquake (SSE). Passive failures of the cooling tower spray or fill systems are considered extremely unlikely due to their materials of construction, supporting systems and Seismic Category I design.

The UHS fans are designed to withstand the effects of a hurricane or tornado including differential pressure effects, overspeed, and the impact of differential pressure effects on other equipment located within the cooling tower structure (e.g., capability to function, potential to become missile/debris hazard). The method to be used to protect the UHS fans from overspeed due to a hurricane or tornado effects will be a brake system or the resistance of the fan gear reducer.

To prevent the entrainment of debris from the UHS cooling tower, each cell of the UHS cooling tower includes a debris screen located between the cooling tower internals and the ESW pump.

To account for potential recirculation and interference effects of the cooling towers, an inlet wet bulb correction factor is used. A COL applicant that references the U.S. EPR design certification will confirm that the site characteristic sum of 0% exceedance maximum non-coincident wet bulb temperature and the site-specific wet bulb correction factor does not exceed the value provided in Table 9.2.5-2. If the value in

The cooling towers must operate for a nominal 30 days following a LOCA without requiring any makeup water to the source or it must be demonstrated that replenishment or use of an alternate or additional water supply can provide continuous capability of the heat sink to perform its safety-related functions. The tower basin contains a minimum 72-hour supply of water. After the initial 72 hours, the site-specific emergency makeup water system will provide sufficient flow rates of makeup water to compensate for system volume losses for the remaining 27 days. The normal blowdown isolation valves and the normal filter blowdown isolation valves provide automatic isolation of the ESWS from downstream non-safety-related blowdown piping under DBA conditions to prevent loss of ESW inventory. The emergency blowdown isolation valves and the emergency filter blowdown isolation valves provide automatic isolation of the ESWS under DBA conditions to prevent loss of ESW inventory. The emergency blowdown discharges outside of the Essential Service Water Pump Building (ESWPB) at an elevation above the flood level. The emergency blowdown pipe exiting the building is protected from hurricane and tornado generated missiles by the building structure. The ESW emergency makeup water system also provides isolation of the normal makeup water system from the tower basins under DBA conditions to prevent loss of ESW inventory.

The heat load after 72 hours post-DBA is lower than the peak heat load due to a reduction in the decay heat from the reactor. Consequently, the makeup flow rate required after 72 hours is lower than the peak condition. Since the UHS basin contains at least 72 hours of water inventory for the DBA, in combination with the worst ambient evaporation conditions, the UHS emergency makeup is not required to start until after 72 hours. At that point, the makeup requirements are diminished. The minimum makeup supply rate is based on the maximum evaporation rate at the end of the 72 hour period post-DBA and considers such losses as drift, seepage and valve seat leakage.

During the 27 days following the 72-hour post-accident period the UHS cooling towers are capable of removing the design basis heat load without exceeding the maximum specified temperature limit for ESWS with minimum specified water inventory available and the most limiting site-specific ambient conditions that are assumed for heat removal. Analyses will demonstrate that the cooling towers are capable of removing the design basis heat load without exceeding the maximum specified temperature limit for ESWS. Transient analyses shall be completed by qualified individuals and the results will be documented in the Cooling Tower Design Report. This report shall include:

1. Performance curves for the cooling towers.

2. The period of record for the temperature data and the specific worst case periods used in the analysis, together with selection methods and validation techniques for the meteorological data.

divisions 3 and 4 are located inside the EPGB located on the opposite side of the RB. Each division has a separate and independent HVAC system. The HVAC systems for each of the four divisions are identical.

The air intake and exhaust stack of the EPGBVS are located such that exhaust gases being drawn into the air inlet stream are limited to an insignificant level. The exhaust stack is located approximately 70 feet from the air intake, and the exhaust air flow is directed away from the air intake flow.

One of the divisions of the EPGBVS is illustrated in Figure 9.4.9-1—Emergency Power Generating Building Ventilation System. The other three divisions are identical.

The EPGBVS consists of following subsystems for each division:

- Ventilation of diesel hall.
- Ventilation of electric room.
- Ventilation of main tank room.

Ventilation of Diesel Hall

The outside air is drawn into the HVAC supply room through an air intake screen or grill which prevents large objects from entering the air intake. The fresh air intake is located approximately fifty feet above grade elevation and is protected against hurricane and tornado missiles. The screen or grill is heated during the winter to prevent ice buildup.

The air from the HVAC supply room is supplied through two separate air trains which include back draft damper, prefilter, and supply fan. Each diesel hall supply and exhaust fans maintain the diesel hall temperature between 59°F and 140°F. The supply air is delivered through ductwork to the diesel hall.

An additional non-safety-related air supply and exhaust ventilation system to the diesel hall is also installed that operates when the large safety-related supply and exhaust system is not required to operate during maintenance or when the moderate outside temperature does not allow the large supply and exhaust fans to operate. The non-safety-related air supply is drawn from the HVAC supply room, the system includes an air intake screen or grill, backdraft damper, prefilter, supply fan, motor operated damper, and manual damper. The non-safety-related air exhausts to the HVAC air exhaust room, the system includes a motor operated damper, exhaust fan and backdraft damper.

The non-safety-related ventilation system prevents frequent starting and stopping of the large safety-related supply and exhaust fans. A safety-related temperature sensor in the diesel hall controls operation of one or both safety-related supply/exhaust fans as required to maintain design temperature in the diesel hall. Initially, the non-safety fans operate, and as the diesel hall temperature increases both safety-related supply/exhaust fans start operating. Operation of safety-related fans shuts down the non-safety fans and closes the motor operated dampers. A separate safety-related temperature sensor in the diesel hall provides low/high room temperature alarm in the MCR. This sensor also closes the safety-related motor operated dampers located on the non-safety-related air supply/exhaust system when the diesel hall temperature reaches at or below 59°F.

During winter conditions, when the EDGs are not in operation, the air in the diesel hall is recirculated through four electrical ~~air~~ fan heaters. These fans are controlled by local thermostats to maintain the required minimum temperature.

The exhaust air from the diesel hall is directed to the HVAC exhaust room through two separate ducts which include an exhaust fan and a back draft damper. The exhaust plenum is split into two sections: one is for the diesel engine exhaust, and the other is for HVAC exhaust. This separation of exhaust prevents diesel exhaust back pressure from affecting the HVAC exhaust ventilation fans. This boundary prevents inadvertent entry of diesel engine exhaust into the diesel room if one of the HVAC exhaust damper fails to close. This partition also protects the HVAC equipment and improves working environment inside the area.

Ventilation of Electric Room

A non-safety-related inlet air supply for the electrical room is drawn from outside air through a motor operated damper, manual damper, prefilter, refrigerant evaporator cooler, and fan. The operation of this unit is automatically controlled by a room thermostat that maintains the electrical room temperature between 40°F and 113°F. A safety-related temperature sensor located outside under a hurricane and tornado protective hood, sends a signal to open or close the safety-related motor operated damper that is located on the non-safety-related inlet air supply. This damper automatically closes when outside air temperature is below 50°F or above 100°F. This prevents entry of hot or cold outside air. The non-safety-related cooling system operates only when the EDGs are not operating. A backdraft damper is installed at the boundary of electrical room and diesel hall to allow the electrical room air to exhaust to the diesel hall.

A safety-related cooling system for the electrical room operates when the EDGs are also operating. This system recirculates the electrical room air through an air conditioning unit that consists of ~~fire dampers,~~ manual damper, prefilter, HEPA filter, cooling coil, moisture separator, and supply fan. The fan air flow maintains electrical room temperature within the design temperature limits of 40°F and 113°F. The water for the cooling coil is supplied from the ESW system. The recirculated air from the electrical room is controlled to maintain ambient conditions inside the electrical room.

- Manual balancing damper.
- Prefilter.

Each ESWPB has two safety-related room air heater units to prevent freezing within the ESW pump rooms during winter.

- Cooling coils, which cool the recirculation air to the required supply air temperature, have a total cooling capacity of ~~619,400~~640,000 Btu/hr. The cooling coils are supplied with water from the ESWS pump and the water is discharged into the respective cooling tower basin. Manual isolation valves are provided to isolate the cooling coils for maintenance.
- Moisture separator, which drains the condensate to the cooling tower basin.
- Heaters, which heat the recirculation air during winter conditions to maintain the minimum required temperature.
- Supply air recirculation fans, are designed to provide an air flow rate of ~~30,000~~ 115,000 scfm.
- Supply air louver dampers.
- Motor operated outside air inlet and outlet isolation dampers.

Non-Safety Related Cooling Unit

The non-safety-related cooling units in each pump house pull in outside air through a grille protected by a hurricane or tornado barrier. The outside air is mixed with recirculated room air through balancing dampers and processed through an air conditioning train. The non-safety-related air conditioning train for each building is comprised of the following components:

- Supply ducting with bird screen.
- Manual balancing dampers.
- Prefilters.
- Split system refrigerant air conditioning cooling coil.
- Supply air fan.

9.4.11.2.2 Component Description

The major safety-related components of the ESWPBVS are listed in the following paragraphs, along with the applicable codes and standards. Table 3.2.2-1 provides the seismic design and other design classifications for components in the ESWPBVS.

All indicated changes are in response to RAI 541, Question 02-3

are not in operation. The safety-related cooler for a particular ESWPB will operate when the ESW pump in that building is in operation. The non-safety-related cooler can operate concurrent with the safety-related cooler with or without the ESW pumps in operation. A safety-related temperature sensor (located outside under the hurricane and tornado protective hood for inlet outside air) sends a signal to open or close the safety-related inlet and outlet motor operated isolation dampers when the outside air temperature is above 100°F or below 50°F. This will prevent the entry of the hot or cold outside air, which could allow the temperature in the ESW building to fall above or below the maximum/minimum design temperature of 113°F/41~~0~~°F.

During winter, the room air is heated by two safety-related wall mounted electric heaters. Local thermostats start and stop the safety-related heater units to maintain the ESW pump room temperature between 50°F and 100°F.

Abnormal Operating Conditions

If one or more components of the ESWPBVS fail, the ESWPBVS is not able to maintain the required ambient conditions in the affected building. Because there are four independent ESWS pump buildings, the failure in one building does not affect the other three buildings.

Loss of Off-Site Power

In the event of loss of offsite power (LOOP), the safety-related ESWPB cooling system and room air heaters continue to operate. The power is supplied from the Class 1E emergency power supply system (EPSS).

Station Blackout

In the event of station blackout (SBO), the ESWPBVS is not operable.

Plant Accident Conditions

The safety-related ESWPB cooling system and room air heaters are required to operate during design basis accident conditions. Even if the ESWS pumps are not required to operate, the safety-related ESWPBVS maintains conditions in the ESWS pump buildings in case the ESWS pumps are required to operate.

9.4.11.3 Safety Evaluation

The ESWPBVS has sufficient cooling capacity to maintain the pump room temperature below 113°F when the ESWS pump motors are operating at rated load and the outside air is at the maximum site design ambient temperature of 115°F. The heater is controlled by a local temperature control system having a predetermined temperature setpoint.

with an independent visual level indication system that provides local indication of the tank level.

The exterior surfaces of the tanks are painted for corrosion protection. The interior surfaces of the tanks are coated with a corrosion resistant material.

Fuel Oil Unloading Station

The fuel oil unloading station enables the transfer of fuel oil from a bulk fuel oil carrier to the storage tank. There are two unloading stations for each fuel oil storage tank. The unloading stations are separated by distance and out of line of sight. The unloading stations are located above the flood level. The fill and pump-out lines are equipped with locking caps. Federal, state, and local codes and regulations (e.g., NFPA30, and 40 CFR Part 112) apply to the fuel unloading station. The design provides sufficient features and administrative control on the storage tank outside fill, and pump-out lines to protect against damage from vehicles, hurricane, tornado, missiles, floods, extreme cold, and accidental contamination.

The fill piping contains an inline filter to preclude sediment particles from being introduced into the storage tank during fuel unloading. Each of the four fuel oil storage tanks is equipped with a pump-out line. The configuration is in conjunction with the fill line to provide connection of a temporary filtration unit for periodic recirculation and filtration of the fuel inventory when the sampling and testing program shows a need to reduce entrained particulate matter.

Fuel Oil Transfer Pump

Two 100 percent transfer pumps are provided for each EDG. Each pump motor is powered from the same Class IE bus associated with its EDG. The capacity of each transfer pump is approximately twice the consumption rate of the EDG at its continuous rating. The pumps are protected by a common duplex suction strainer and individual pressure relief valves. The pumps discharge to a common duplex filter prior to fuel oil entering the fuel day tank. One pump is designated as the primary pump and the second pump is designated as the standby pump, the latter serving in the event of a failure of the primary pump.

Fuel Oil Transfer Pump Duplex Suction Strainers

The function of the strainer is to remove any entrained contaminants to protect the pump. There is a single set of duplex strainers in the supply line to the transfer pumps. Each element is sized for operation of both transfer pumps simultaneously. The fuel oil duplex strainers are designed for servicing on line.

- Safety-related portions of the MSSS outside containment are protected from internal missiles by the separated trains in the valve room, so that at most one valve station is affected by missiles. Further information on missile protection is provided in Section 3.5.

- Consistent with the guidance in RG 1.115, Position C.1, the TG location and axis is favorably oriented with respect to the containment such that turbine missile impacts on safety-related portions of the MSSS from a single U.S. EPR plant are precluded. Refer to Section 3.5.1.3 for the evaluation of turbine missiles.

- Consistent with RG 1.117, Appendix Positions 2 and 4, the safety-related portions of the MSSS are protected against the effects of tornado and hurricane missiles by the external walls and roofs of the structures containing these portions of the system, as described in Section 3.5.

- Load drops on safety-related portions of the MSSS are precluded during operations, requiring the MSSS to be operable by administrative controls implemented in plant procedures. The controls include the use of handling devices suitable for the load being lifted and limitations on lift heights and lift paths over safety-related components.

- The MSSS design considers steam hammer and relief valve discharge loads to make sure system safety functions can be performed. Refer to Section 3.12 for a description of piping design and piping supports design. Loads from relief valve thrusts and sudden closure of valves (hammer) is included in the piping analyses. Operating and maintenance procedures will include precautions to prevent steam hammer and relief valve discharge loads. Piping in the MSSS is required to be properly warmed and drained of condensate during startup. System maintenance and operating procedures will include guidance and precautions to be exercised during system and component testing and changing valve alignments to confirm that valves in the MSSS operate properly.

- The MSSS design includes protection against water entrainment by sloping the main steam piping to drained low points.

The design of the safety-related portions of the MSSS satisfies GDC 5 regarding sharing of systems. Safety-related portions of the MSSS are not shared among nuclear power units.

The design of the safety-related portions of the MSSS satisfies GDC 34 regarding residual heat removal from the reactor coolant system.

- The MSSS provides residual heat removal by venting steam from the SGs via the MSRTs to the atmosphere and cooling down the reactor coolant system to the point of placing the RHRS in operation.

- The design of the safety related portions of the MSSS is consistent with the positions in BTP 5-4 (Reference 4), as it relates to the design requirements for residual heat removal. The MSRTs are safety-grade with safety-grade actuators,

11.4.1.2.1 Capacity

The facilities in the Radioactive Waste Processing Building have the capacity to store a minimum of 7.5 years' volume of solid waste (excluding dry active waste) resulting from plant operation. The solid wastes can be stored in one of two onsite storage areas in the Radioactive Waste Processing Building (see Figure 12.3-52). One area is a tubular shaft store for the higher activity drums and the other is a drum store for low activity drums. The storage area has a capacity of approximately 200 drums in the tubular shaft storage and approximately 350 drums in the drum store. When off-site disposal options for Class B and C wastes are not available, the U.S. EPR solid waste processing system provides the flexibility necessary to treat potential Class B and C waste types such that the final container for these wastes are 55-gallon waste drums. The normal container for some of these waste types is high-integrity container (HIC), however the solid waste management system is able to store these wastes in drums if necessary. Assuming the maximum annual shipping volume of solid waste in Table 11.4-1 (with the exception of dry active waste) is stored in 55-gallon drums and must be placed in the drum storage area or tubular shaft storage area, there would be 72.9 drums annually that would need to be stored. This results in a drum storage capacity of approximately 7.5 years.

Storage and offsite shipping of solid radioactive waste maintains exposure ALARA to personnel onsite or offsite under normal conditions or extreme environmental conditions, such as tornados, hurricanes, floods, or seismic events. The solid waste management system is designed with sufficient waste accumulation capacity and redundancy to allow temporary storage of the maximum generated waste during normal plant operation and AOOs.

The estimated annual volume of solid waste generated in the plant and shipped offsite is provided in Table 11.4-1—Estimated Solid Waste Annual Activity and Volume.

A COL applicant that references the U.S. EPR design certification will address plant-specific commitments to address the long-term storage of LLRW beyond the provisions described in the U.S. EPR design certification when such storage capacity is exhausted and describe how additional onsite LLRW storage or alternate LLRW storage will be integrated in plant operations. To address the need for additional storage, the commitment will address the requirements of 10 CFR Part 20, Appendix B (Table 2, Column 1 and 2); dose limits of 10 CFR 20.1301, 20.1302, and 20.1301(e) in unrestricted areas; Part 20.1406(b) in minimizing the contamination of plant facilities and environs; and design objectives of Sections II.A, II.B, II.C, and II.D of Appendix I to 10 CFR Part 50. The design and operations of additional onsite storage capacity will be integrated in the plant-specific process control program and consider the guidance of SRP Section 11.4 and Appendix 11.4-A, Regulatory Guides 1.206, 4.21 and 1.143, IE Bulletin 80-10, industry standards, and NEI 08-08.

B 3.7 PLANT SYSTEMS

B 3.7.19 Ultimate Heat Sink (UHS)

BASES

BACKGROUND

The UHS provides a heat sink for the removal of process and operating heat from safety related components during an anticipated operational occurrence (AOO) or postulated accident. During normal operation, and a normal shutdown, the UHS also provides this function for the associated safety related and non safety related systems. The safety related function is covered by this LCO.

The UHS consists of four separate safety related, cooling water trains. Each train consists of one mechanical draft cooling tower, associated basin, piping, valving, and instrumentation. Each safety related 2-cell Seismic Category I mechanical draft cooling tower rejects energy from the essential service water (ESW) fluid to ambient and returns the cooled fluid to the UHS cooling tower basin, from which the ESW pumps take suction. Each UHS cooling tower basin is sized for 3 days of post loss of coolant accident (LOCA) operation and ensures adequate volume for the required net positive suction head (NPSH) for the associated ESW pump. Post LOCA evaporative losses are replenished by a safety related Seismic Category I source of makeup water. The train associated safety related make-up source delivers water to each basin at ≥ 300 gpm to maintain the NPSH for the ESW pump for up to 30 days following a LOCA.

The mechanical draft cooling towers and basins are safety related, Seismic Category I structures sized to provide heat dissipation for safe shutdown following an accident. The cooling tower is protected from tornado and and hurricane missiles.

[The Seismic Category I makeup necessary to support 30 days of post accident mitigation is site specific and details are to be provided by the COL applicant.]

Additional information about the design and operation of the UHS is presented in FSAR Section 9.2.5 (Ref. 1).

In terms of non-LRF containment failure release categories RC206 (small containment isolation failure) and RC504 (long term containment failure without MCCI and with failed SAHRS) are important contributors.

~~In the absence of the specific challenges and bypasses of containment seen in the internal events analysis, the results for LRF for fire events are dominated by severe accident phenomenological issues. The specific issue for fires is the possibility of an accelerated flame arising from hydrogen combustion in the lower or middle equipment rooms during the in-vessel phase of a high pressure core melt. Further background discussion on the analysis of this issue is provided in Section 19.1.4.2.2.4.~~

~~As also discussed in Section 19.1.4.2.2.4 for internal events, sequences involving containment failure due to loads from an accelerated flame originating in the lower, middle or upper equipment rooms prior to vessel failure are visible contributors to LRF. The key features and assumptions of the analysis of accelerated flames are discussed in Section 19.1.4.2.2.4 and not repeated here.~~

~~The phenomena of thermally-induced steam generator tube rupture, which was assessed as having a large probability for equivalent two-inch seal LOCAs in conjunction with a depressurized secondary side and an absence of feedwater to the SGs, also features in the results (i.e., 13 percent contribution to LRF). Seal LOCAs are a contributor to the fire CDF, as discussed in Section 19.1.5.3.2.3. Sensitivity studies show that LRF did not significantly increase due to this phenomenon even in the bounding case of assumed concurrent unavailability of feedwater and depressurization functions.~~

~~Despite the dominance of a single phenomenological issue for LRF, it is noted that LRF is only approximately two percent of the CDF for fire events.~~

~~Other phenomenological challenges were not identified as leading to significant probabilities of large release.~~

19.1.5.4 Other Externals Risk Evaluation

The design certification scope of external event screening includes an assessment of high winds, hurricanes, and tornadoes and external flooding as described below.

A COL applicant that references the U.S. EPR design certification will perform the site-specific screening analysis and the site-specific risk analysis for external events applicable to their site.

19.1.5.4.1 High Winds, Hurricane, and Tornado Risk Evaluation

All U.S. EPR Seismic Category I structures are designed to meet the following standards for high winds, hurricanes, and tornadoes.

High Winds

The U.S. EPR Seismic Category I structures are designed to withstand high wind load characteristics as specified in NUREG-0800, Section 3.1.1. The EPR Seismic Category I structures are specifically designed for a basic wind speed of ~~145~~230 mph. ~~This value bounds all locations within the U.S. except the extreme southern tips of Louisiana and Florida (SEI/ASCE 7-05).~~

Tornado and Hurricane Wind Loads

The U.S. EPR Seismic Category I structures are designed to meet the design-basis tornado wind characteristics of Tornado Intensity Region 1 and the hurricane wind characteristics as specified in NUREG-0800, Section 3.3.2. Tornado Intensity Region 1 is characterized by a maximum tornado wind speed of 230 mph (184 mph maximum rotational speed, 46 mph maximum translational speed). ~~These design-basis tornado wind characteristics are bounding for all U.S. regions within the contiguous 48 states.~~Hurricane is characterized by a selected maximum hurricane wind speed of 230 mph. These hurricane wind characteristics are bounding for all U.S. regions within the contiguous 48 states except Florida Keys and very southwest tip of Florida.

Tornado and Hurricane Missiles

The U.S. EPR Seismic Category I structures are designed to the design-basis tornado missile characteristics of Region 1 (most limiting U.S. region) and design-basis hurricane missile characteristics as specified in NUREG-0800, Section 3.5.1.4. The design basis tornado and hurricane missiles include (1) a massive high-kinetic-energy missile that deforms on impact, (2) a rigid missile that tests penetration, and (3) a small rigid missile of a size sufficient to pass through any opening in protective barriers.

U.S. EPR Seismic Category I structures include:

- Reactor Building (RB) and Reactor Building annulus.
- Safeguard Buildings (SBs).
- Emergency Power Generating Buildings (EPGB).
- Essential service water (ESW) Pump Structures.
- ESW Cooling Water Structures.
- Fuel Building (FB).
- Vent Stack ~~(VSTK)~~.

Based on the U.S. EPR design, a tornado, hurricane, or high wind event will not have a significant impact on safety-related equipment. The most limiting impact from a tornado, hurricane, or high wind would likely be a LOOP.

The U.S. EPR has a robust design to cope with a LOOP event. Four independent EDGs (protected within the EPGB) are available to provide power to the safety buses. Although not specifically protected from high winds and tornado, two SBO diesels, which are located separately from the EPGB, are likely to be available to backup the EDGs.

High Winds, Hurricane, and Tornado Evaluation Conclusion

The preceding high winds, hurricane, and tornado structural design features, in combination with the U.S. EPR onsite divisional and backup power supplies, provide a robust design against potential high wind, hurricane, and tornado hazards. ~~Therefore, the risk from high wind and tornado events is judged not significant.~~

19.1.5.4.2 External Flooding Evaluation

Safety-related systems and components housed in the Seismic Category 1 buildings are protected from external floods and groundwater by the flood protection measures summarized below. Refer to Section 2.4 and Section 3.4 for further information on external flood design protection features.

- Structures, including penetrations (e.g., piping and cable penetrations), are designed for the buoyancy loads and hydrostatic pressure loads resulting from groundwater pressure and external flooding.
- Portions of the buildings located below grade elevation are protected from external flooding by water stops and water proofing. All exterior wall or floor penetrations located below grade are provided with watertight seals. No access openings or tunnels penetrate the exterior walls of the Nuclear Island below grade.
- The roofs of the buildings are designed to prevent the undesirable buildup of standing water in conformance with RG 1.102. The roofs of the structures do not have parapets that could collect water. The maximum rainfall rate for roof design is 19.4 inches per hour. The design static roof load for rain, snow and ice is 100 pounds per square foot, which includes the weight of the 100-year return period snow pack and the weight of the 48-hour probable maximum winter precipitation.
- The structures hardened against airplane crash have exterior doors resistant to intrusion by aircraft fuel, and therefore these exterior doors would also provide additional protection against potential flood water.

External Flooding Evaluation Conclusion

The preceding external flooding design features, in combination with the U.S. EPR requirements for building location relative to the probable maximum flood (PMF) and