ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA NP INC) [Ronda.Pederson@areva.com]
Sent: Thursday, November 12, 2009 5:59 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 283, FSAR Ch. 3, Supplement 1
Attachments: RAI 283 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. (AREVA NP) provided a schedule for responses to the 4 questions of RAI No. 283 on October 2, 2009. The attached file, “RAI 283 Supplement 1 Response US EPR DC.pdf” provides technically correct and complete responses to 3 of the remaining 4 questions, as committed.

Appended to this file are the affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 283 Questions 03.03.02-4, 03.08.01-38, and 03.08.03-20.

The following table indicates the respective page(s) in the response document, “RAI 283 Supplement 1 Response US EPR DC.pdf” that contain AREVA NP’s response to the subject questions.

Question #	Start Page	End Page
RAI 283 — 03.03.02-4	2	2
RAI 283 — 03.08.01-38	3	4
RAI 283 — 03.08.03-20	5	6

The schedule for technically correct and complete responses to the remaining question is unchanged and provided below:

Question #	Response Date
RAI 283 — 03.08.01-37	December 10, 2009

Sincerely,

Ronda Pederson
ronda.pederson@areva.com
Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
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From: Pederson Ronda M (AREVA NP INC)
Sent: Friday, October 02, 2009 4:55 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC); VAN NOY Mark (EXT)
Subject: Response to U.S. EPR Design Certification Application RAI No. 283, FSAR Ch. 3

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 283 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 4 questions cannot be provided at this time.

The following table indicates the respective page(s) in the response document, "RAI 283 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 283 — 03.03.02-4	2	2
RAI 283 — 03.08.01-37	3	3
RAI 283 — 03.08.01-38	4	4
RAI 283 — 03.08.03-20	5	5

A complete answer is not provided for 4 of the 4 questions. The schedule for a technically correct and complete response to each of these questions is provided below.

Question #	Response Date
RAI 283 — 03.03.02-4	November 12, 2009
RAI 283 — 03.08.01-37	December 10, 2009
RAI 283 — 03.08.01-38	November 12, 2009
RAI 283 — 03.08.03-20	November 12, 2009

Sincerely,

Ronda Pederson

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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Wednesday, September 02, 2009 6:44 PM
To: ZZ-DL-A-USEPR-DL
Cc: Jeng, David; Xu, Jim; Samaddar, Sujit; Miernicki, Michael; Patel, Jay; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 283 (2718, 3611,3614), FSAR Ch. 3

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on August 25, 2009, and on September 2, 31, 2009, 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/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 951

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From: Pederson Ronda M (AREVA NP INC)

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Response to

Request for Additional Information No. 283, Supplement 1

9/02/2009

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.03.02 - Tornado Loads
SRP Section: 03.08.01 - Concrete Containment
SRP Section: 03.08.03 - Concrete and Steel Internal Structures of Steel or Concrete Containments

Application Section: FSAR Ch 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

Question 03.03.02-4:

Follow-up to RAI Question Number 3.3.2-1

As originally requested in RAI 3.3.2-1, provide the basis for the values used in the FSAR for the exposure coefficient Kz and the importance factor I.

Response to Question 03.03.02-4:

The values of "K_z"and "I" in U.S. EPR FSAR Tier 2, Section 3.3.2.2 will be replaced with values recommended by NUREG-0800, SRP Section 3.3.2:

K_z = 0.87, tornado wind velocity pressure is considered constant with height.

I = 1.15, importance factor.

U.S. EPR FSAR Tier 2, Section 3.3.2.2.1 will be deleted.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.3.2.2 and Section 3.3.2.2.1 will be revised as described in the response and indicated on the enclosed markup.

Question 03.08.01-38:

Follow-up to RAI Question Number 3.8.1-4

In response to item (1) of this RAI, the applicant indicates that the jurisdictional boundary selected for the U.S. EPR, as applicable to the common basemat, is a cylinder aligned with the outside face of the reactor containment building wall (Figure 03.08.01-4-1 Jurisdictional Boundaries).

In response to item (2) of this RAI, the applicant acknowledges that ASCE/SEI 4-98 is not a code and indicates that the reference will be removed from the list of codes in EPR FSAR Sections 3.8.1.2.1 and 3.8.2.2.1. The staff notes that the markup in the RAI deleted references to ASCE/SEI 4-98 from U.S. EPR FSAR, Tier 2, Sections 3.8.3.2.1 and 3.8.4.2.1 in addition to Sections 3.8.1.2.1 and 3.8.2.2.1. However, ASCE 4-98 is still generally referred to for seismic analysis and design in FSAR Sections 3.8.3.4.4 and 3.8.4.4.1. Furthermore, the applicant lists three specific provisions of ASCE/SEI 4-98 (items 2-a, 2-b, and 2-c) utilized in the analysis and provides the technical basis for the use of two of the three provisions (items 2-b and 2-c). Regarding item 2-b, the staff understands that passive resistance of the soil is relied upon for the stability evaluation of plant structures. Therefore, the soil pressures to be used for design of foundations should consider both seismic induced soil pressure loads and soil passive pressures.

The following additional information is needed to resolve this RAI:

Regarding item (1) of this RAI, the staff notes that Interpretation No. 12 (III-2-83-01) of the ASME Code, Section III, states that when the containment foundation is integral with other building foundations: "The portion of the common foundation directly beneath the containment vessel, including any additional peripheral volume for anchoring of the containment shell reinforcing, shall be constructed in accordance with the rules of Section III, Division 2, when required by the Design Specification." Therefore, to complete the response to item (1) of this RAI, the applicant is requested to confirm that an additional peripheral volume for anchoring of the containment shell reinforcing is included within the jurisdictional boundary of the ASME Code Section III, Division 2 basemat. This additional peripheral volume should also be indicated in Figure 03.08.01-4-1 Jurisdictional Boundaries. In addition, the description of the jurisdictional boundary and loading considerations between the ASME containment and the other non-ASME structures, which are discussed in the RAI response, needs to be summarized in the appropriate locations in the EPR FSAR Section 3.8.

Regarding item (2) of this RAI, the applicant is requested to confirm that the foundations of all Seismic Category I structures have been designed for the envelope of seismic induced soil loads and soil passive pressures. In addition, the applicant is requested to delete all discussions and references to ASCE 4-98 (wherever they appear in the FSAR including Sections 3.8.3.4.4 and 3.8.4.4.1) when no technical basis has been provided for their use.

Response to Question 03.08.01-38:

1. Common basemat jurisdictional boundary for the U.S. EPR is aligned with the outside of the Reactor Shield Building wall. This is indicated in Figure 03.08.01-38-1 (Note 2). This figure will be added to U.S. EPR FSAR Tier 2 as Figure 3.8-118. A discussion of loading considerations with respect to structure-to-structure effects is provided in U.S. EPR FSAR Tier 2, Section 3.8.1.3.2, Section 3.8.3.3.2, Section 3.8.4.3.2 and Section 3.8.5.3. This information will be revised to include a reference to Figure 3.8-118 regarding jurisdictional boundaries.

2. Where no technical justification has been provided for their use, references to ASCE 4-98 have been removed from U.S. EPR FSAR Tier 2, Section 3. Remaining U.S. EPR FSAR Tier 2, Section 3.8 references to ASCE 4-98 are technically justified. Technical justification for references to ASCE 4-98 regarding the 100-40-40 rule are discussed in U.S. EPR FSAR Tier 2, Section 3.8.3.4.4 and Section 3.8.4.4.1.

   Compliance with ASCE 4-98 for determining seismic induced soil pressure is in accordance with guidance of SRP 3.8.1 and SRP 3.8.4. References to ASCE 4-98 for seismic induced soil pressures will not be changed in U.S. EPR FSAR Tier 2, Section 3.8.4.3.1, Section 3.8.4.4.1, Section 3.8.4.4.2, Section 3.8.4.4.4, and Section 3.8.5.4.1.

   U.S. EPR Seismic Category I foundations are designed for the CSDRS envelope of seismic induced soil loads and soil passive pressures.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.8 will be revised as described in the response and indicated on the enclosed markup.

Question 03.08.03-20:

Follow-up to RAI Question Number 3.8.3-2

In response to the first part of this RAI, the applicant indicates that the sentence “Limits for allowable loads on concrete embedments and anchors are in accordance with Appendix B of ACI 349-2006 and guidance given in RG 1.199” already appears in EPR FSAR Section 3.8.4.5. However, the staff notes that Section 3.8.4.5 actually references ACI 349-2001 not ACI 349-2006. Furthermore, RG 1.199 endorses ACI 349-2001 subject to certain conditions and limitations.

In the second part of this RAI, the applicant states that ACI 349-2001 adequately addresses the issues of capacity, installation, and testing raised in NRC IE Bulletin 79-02. In addition, the applicant mentions that the issue of base plate flexibility is addressed by AISC design guidelines.

The following additional information is needed to resolve this RAI:

1. To complete the response to item (1) of this RAI, the applicant is requested to clarify which edition of ACI 349 is considered for the design and installation of anchor bolts. If ACI 349-2006 is intended, the applicant is further requested to confirm that none of the provisions in this later document are less stringent than those contained in ACI 349-2001 and RG 1.199, which are applicable to the design and installation of anchors in the EPR plant.
2. To complete the response to item (2) of this RAI, the applicant is requested to: (1) identify the AISC guideline document referred to for base plate design, (2) to confirm that this AISC document and ACI 349-2001 (or 2006 whichever is selected) conforms to all of the provisions of NRC IE Bulletin 79-02, and (3) identify where the key provisions from the IE Bulletin are captured in the AISC/ACI 349 documents. If these documents by themselves do not capture all of the applicable provisions in the IE Bulletin, then the FSAR should be revised to include the need to also satisfy the requirements of IE Bulletin 79-02, or to provide the technical basis for not doing so.

Response to Question 03.08.03-20:

1. Design and installation of anchors is performed using the provisions of ACI 349-06, Appendix D with the exception of “Condition A” strength-reduction factors, and with the exceptions noted in RG 1.199. The use of ACI 349-06, Appendix D, instead of the NRC approved ACI 349-01, Appendix B, was introduced with the response to RAI 155, Question 03.08.03-3 and is reconciled in a proprietary AREVA NP, Inc., (AREVA NP) document, which is available for inspection at AREVA NP offices.

2. The applicable design code for safety-related steel members is ANSI/AISC N690-1994 (with Supplement 2) and is identified in U.S. EPR FSAR Tier 2, Section 3.8.3.2.3 and Section 3.8.4.2.3.

   The referenced NRC IE Bulletin 79-02 in the question was issued in 1979, prior to the development of the ACI 349 appendix for embedment and anchor design, and was prompted by support failures and lack of consistency in the anchor design, testing, and installation. As a result of research performed to address issues identified by NRC IE Bulletin 79-02, the ACI 349 guideline for anchor design was released and RG 1.199 was issued. RG 1.199, Part B includes a discussion on its development and correlation with NRC IE Bulletin 79-02.

SRP 3.8.3, SAC-4A, iii and SRP 3.8.4, SAC-4A, indicate that design and analysis of anchors (steel embedments) are acceptable if they comply with ACI 349, and RG 1.199.

U.S. EPR FSAR Tier 2, Section 3.8.3.4 and Section 3.8.4.4.1 state that concrete embedments and anchors are designed in accordance with ACI 349-06, Appendix D (with exception as noted above) and RG 1.199 guidelines, which in turn conforms to guidance provided by NRC IE Bulletin 79-02.

U.S. EPR FSAR Tier 2, Section 3.8 references to ACI 349-2006 will be revised for clarification, as appropriate.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.8.1.2.1, 3.8.1.5, 3.8.3.2.1, 3.8.3.2.3, 3.8.3.5, 3.8.4.2.1, 3.8.4.2.3, 3.8.4.4.1, 3.8.4.5, 3.8.5.4.1, 3.8.5.5, and 3.8.6 will be revised as described in the response and indicated on the enclosed markups.

U.S. EPR Final Safety Analysis Report Markups

qz = 0.00256 Kz Kzt Kd V2 I (lb/ft2),

Where:

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

03.03.02-4

K_z = ~~1.0~~0.87, tornado wind velocity pressure is considered constant with height.

~~(This is an exception to NUREG 0800 SRP Section 3.3.2, which recommends K_z = 0.87).~~

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

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

V = 230 mph, tornado maximum wind speed in miles per hour.

I = ~~1.0~~1.15, ~~the~~ importance factor ~~is taken as unity~~.

~~(This is an exception to NUREG 0800 SRP Section 3.3.2, which recommends I = 1.15).~~

~~Based on the stated definitions, the expression for effective tornado wind velocity pressure reduces to the following:~~

~~qz = 0.00256 V2~~

Effective 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.

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

The following combinations of the parameters of the total tornado load (W_t) are evaluated in the design of Seismic Category I structures and structures that have the potential to interact with Seismic Category I structures under tornado load conditions, where W_w is the load from tornado wind effect, W_p is the load from tornado atmospheric pressure change effect, and W_m is the load from tornado missile impact effect:

Wt = Wp

Wt = Ww + 0.5Wp + Wm

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.

03.03.02-4

~~3.3.2.2.1 Note on Values Used~~

~~The use of the values stated previously for K_z = 1.0 and I = 1.0 provides essentially identical results as those recommended in NUREG 0800, SRP Section 3.3.2, for K_z = 0.87 and I = 1.15. That is, the product of the U.S. EPR values is 1.0 x 1.0 = 1.0, whereas the product of SRP Section 3.3.2 values is 0.87 x 1.15 = 1.0005.~~

3.3.2.3 Effect of Failure of Structures or Components not Designed for Tornado Loads

~~Non-Seismic Category I structures are not designed for tornado loads unless their failure during a tornado could adversely affect nearby Seismic Category I SSC. Seismic Category I structures are protected from failure of adjacent non-Seismic Category I structures during a tornado by one of the following methods:~~

- ~~The adjacent non-Seismic Category I structure is designed to resist applicable tornado loadings.~~
- ~~The integrity of a Seismic Category I structure is evaluated for failure of an adjacent non-Seismic Category I structure during a design basis tornado to verify the functionality and continued operation of the Seismic Category I structure during and after the tornado.~~
- ~~A structural barrier(s) is provided to protect the Seismic Category I structure from failure of the adjacent non-Seismic Category I structure as a result of a tornado.~~

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 Vent Stack (VSTK), Nuclear Auxiliary Building (NAB), Radioactive Waste Processing 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 Vent Stack is a steel structure which is categorized as a Seismic Category II structure. It is supported on the roof slab of the Seismic Category I stair tower located between the Seismic Category I Fuel Building and the Seismic Category I Safeguard Building 4. Due to the proximity of the vent stack to other Seismic Category I structures, it is conservatively treated as a Seismic Category I structure for the purposes of global design.

The NAB, 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

Section 3.8.2 contains a description of the penetrations through the containment liner, including the equipment hatch, airlocks, piping penetration sleeves, electrical penetration sleeves, and the fuel transfer tube penetration sleeve.

No load transfer attachments are used at the bottom portion of the liner plate to transfer loads from the concrete RB internal structures into the lower portion of the NI Common Basemat Structure foundation basemat. RB internal structure lateral reaction loads are transferred through the liner plate. This is achieved by lateral bearing on the haunch wall at the bottom of the RB internal structures foundation where it is embedded in concrete above the NI Common Basemat Structure foundation basemat.

Structural attachments to the containment walls and dome include various pipe, HVAC, electrical, and equipment support brackets, as well as the polar crane rail supports. The liner plate is continuously welded to embedded plate areas and areas with thickened plates so that a continuous leak-tight barrier is maintained.

3.8.1.2 Applicable Codes, Standards, and Specifications

The following codes, standards, specifications, design criteria, regulations, and regulatory guides are used in the design, fabrication, construction, testing, and in-service inspection of the RCB (GDC 1, GDC 2, GDC 4, GDC 16, and GDC 50).

3.8.1.2.1 Codes

- ACI 117-90/117R-90, Specification for Tolerances for Concrete Construction and Materials (Reference 6).
- ACI 301-05, Specifications for Structural Concrete for Buildings (Reference 7).
- ACI 304R-00, Guide for Measuring, Mixing, Transporting, and Placing Concrete (Reference 8).
- ACI 305.1-06, Specification for Hot-Weather Concreting (Reference 9).
- ACI 306.1-90, Standard Specification for Cold-Weather Concreting (Reference 10).
- ACI 347-04, Guide to Form Work for Concrete (Reference 11).
- ACI 349-01, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (exception described in Sections 3.8.4.4 and 3.8.4.5) (Reference 12).
- ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D) with the exception of Condition A strength reduction factors even when supplemental reinforcement is provided (Reference 63).

03.08.03-20

part of the plant safeguards and security measures. Aircraft hazard loads are not applicable on the RCB because it is surrounded by other Seismic Category I structures that provide a shield.

- 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 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 those pressure loads that result from a fuel-clad metal-water reaction, an uncontrolled hydrogen burn, and a postaccident condition for the containment inerted by carbon dioxide. RG 1.136, Regulatory Position C.5 provides the loads and load combinations acceptable for analysis and design of containment when exposed to the loading conditions associated with combustible gas. The principal combustible gas for the U.S. EPR is hydrogen. There is no inerting gas system in the U.S. EPR. The containment design pressure is 62 psig based on DBA conditions. RG 1.136, Regulatory Position C.5 and RG 1.7 specify a pressure of 45 psig combined with dead load (D) as a minimum design condition. Therefore, the strains and stresses for the RCB calculated using the U.S. EPR design pressure in the load combinations in Table CC-3230-1 of the ASME BPV Code bounds the results of the pressure specified in RG 1.136 and RG 1.7. See Section 6.2.5 for a description of combustible gas loads.

Missile Loads other Than Wind- 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).

03.08.01-38

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

~~pressure capacity reported is the median pressure capacity for the vertical plane section.~~

~~The equipment hatch cover and cylinder, shown inFigure 3.8-25—Equipment Hatch General Assembly has a cover ultimate pressure capacity based on ASME Section II, Part D material specification minimum required strengths and an elastic, perfectly plastic stress-strain relationship at 400°F. The internal pressure from containment is applied to the convex surface of the cover and non-embedded portion of the cylinder. The ultimate pressure capacity reported corresponds to ASME Service Level C stress limits for the hatch cover and cylinder.~~

3.8.1.4.12 Design Report

Design information and criteria for Seismic Category I structures are provided in Sections 2.0, 2.4, 2.5, 3.3, 3.5, 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5. Design results are presented in Appendix 3E for Seismic Category I structure critical sections.

3.8.1.5 Structural Acceptance Criteria

The limits for RCB allowable stresses, strains, deformations and other design criteria are in accordance with the requirements of Subsection CC-3400 of the ASME BPV Code, Section III, Division 2 and RG 1.136 (GDC 1, GDC 2, GDC 4, GDC 16, and GDC 50). This applies to the overall containment vessel and subassemblies and appurtenances that serve a pressure retaining function, except as noted in Section 3.8.2. Specifically, allowable concrete stresses for factored loadings are in accordance with Subsection CC-3420 and those for service loads are in accordance with Subsection CC-3430.

The limits for stresses and strains in the liner plate and its anchorage components are in accordance with ASME BPV Code, Section III, Division 2, Tables CC-3720-1 and CC-3730-1.

03.08.03-20 Limits for allowable loads on concrete embedments and anchors are in accordance with Appendix ~~B~~D of ACI-349-~~20~~06 (with exceptions stated in Section 3.8.1.2.1, Codes) and guidance given in RG 1.199.

Section 3.8.1.6 describes minimum requirements for concrete, reinforcing, post-tensioning tendons, and the liner plate system for the RCB.

A SIT is performed as described in Section 3.8.1.7.1.

The RCB is stamped to signify compliance with the ASME BPV Code Section III, Division 2.

- ACI 308R-01, Guide to Curing Concrete (Reference 50).
- ACI 308.1-98, Standard Specification for Curing Concrete (Reference 39).
- ACI 311.4R-05, Guide for Concrete Inspection (Reference 40).
- ACI 347-04, Guide to Formwork for Concrete.
- ACI 349-01/349-R01, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary on Code Requirements for Nuclear Safety Related Concrete Structures (exception described in 3.8.4.4 and 3.8.4.5) (GDC 1).
- 03.08.03-20 ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D) with the exception of Condition A strength reduction factors even when supplemental reinforcement is provided (Reference 63).
- ACI 349.1R-07, Reinforced Concrete Design for Thermal Effects on Nuclear Power Plant Structures (Reference 41).
- AISC 303-050, Code of Standard Practice for Steel Buildings and Bridges (Reference 42).
- ANSI/AISC N690-1994, Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities, including Supplement 2, 2004 (GDC 1).
- ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings, American Institute of Steel Construction, including Supplement 1 (Reference 43).
- AISC 348-0400/20042000 RCSC, Specification for Structural Joints Using ASTM A325 and A490 Bolts (Reference 44).
- ANSI/AWS D1.1/D1.1M 2006, Structural Welding Code - Steel.
- ANSI/AWS D1.4-2005, Structural Welding Code - Reinforcing Steel.
- ANSI/AWS D1.6-1999, including January 6, 2005 update, Structural Welding Code – Stainless Steel.
- ANSI/AWS D1.8-2005, Structural Welding Code – Seismic Supplement (Reference 45).
- ASME Boiler and Pressure Vessel Code - 2004 Edition, Section III, Division 2 - Code for Concrete Reactor Vessels and Containments (GDC 1).
- ASME Boiler and Pressure Vessel Code - 2004 Edition, Section III, Division 1 – Nuclear Power Plant Components (GDC 1).
- ASME NOG-1-04, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder).

3.8.3.2.2 Specifications

Industry standards (e.g., those published by the ASTM) are used to specify material properties, testing procedures, fabrication methods, and construction methods. Section 3.8.3.6 addresses the applicable standards used.

Structural specifications cover areas related to the design and construction of the RB internal structures. These specifications emphasize important points of the industry standards for these structures and reduce options that otherwise would be permitted by the industry standards. These specifications cover the following areas:

- Concrete material properties.
- Mixing, placing, and curing of concrete.
- Reinforcing steel and splices.
- Structural steel.
- Stainless steel liner plate and embedments.
- Miscellaneous and embedded steel.
- Anchor bolts.
- Expansion anchors.
- Polar crane.
- Miscellaneous cranes and hoists.

3.8.3.2.3 Design Criteria

- ACI 349-01/349-R01, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary on Code Requirements for Nuclear Safety-Related Concrete Structures (GDC 1).
- ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D) with the exception of Condition A strength reduction factors even when supplemental reinforcement is provided (Reference 63).

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- ANSI/AISC N690-1994, Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities, including Supplement 2 (2004) (GDC 1).

3.8.3.2.4 Regulations

- 10 CFR 50, Appendix A, General Design Criteria for Nuclear Power Plants, GDC 1, GDC 2, GDC 4, GDC 5, and GDC 50.

– 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 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 internally generated missile loads as described in Section 3.5.

3.8.3.3.2 Load Combinations

Load combinations for design of RB internal structures are in accordance with ACI 349-2001 and guidelines of RG 1.142, Revision 2, November 2001 for concrete structures, and in accordance with ANSI/AISC N690-1994 including Supplement 2 (2004) for steel structures (GDC 1, GDC 2, GDC 4, GDC 5 and GDC 50).

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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 ACI 349-2001 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 ACI 349-2001 are adjusted by including the necessary additional independent loadings. For concrete structures, the independent loadings added to the load combinations include buoyant force (F_b) and post-tension stated in Section 3.8.1.2.1, "Codes"), and also in accordance with ANSI/AISC N690-1994 (R2004), including Supplement 2.

3.8.3.4.3 Static Analysis and Design

Dead loads (D), live loads (L), hydrostatic loads (F), pipe reactions (R_o), and normal thermal loads (T_o) are considered in the analysis and design of RB internal structures for the static normal load concrete and service load steel loading combinations. Normal thermal loads are considered as self-relieving for the overall RB internal structures. Concrete and steel members are designed to accommodate these static loads within the elastic range of their section strength.

Static fluid pressure loads are considered for design of the walls and floors of the IRWST and refueling canal. Moving loads are considered for mobile plant equipment (e.g., the polar crane, refueling machine, and other cranes and hoists).

3.8.3.4.4 Seismic and Other Dynamic Analyses and Design

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Seismic analyses and designs of the RB internal structures conform to the procedures described in Section 3.7.2. The procedures in ASCE Standard 4-98, as applicable to the 100-40-40 percent rule, are used in the analysis and design of structural elements and members subjected to load combinations that include seismic loadings. Seismic accelerations are determined from the structural stick model described in Section 3.7.2. These accelerations are applied to the ANSYS model of the RB internal structures as static-equivalent loads at the elevations used in the stick model. Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results.

Seismic SSE (E') loads are obtained by multiplying the dead load and 25 percent of the design live load by the structural acceleration obtained from the seismic analysis of the structure. Seismic loads are also considered due to the mass of fluids in tanks and canals as described herein (Section 3.8.3.4.4). ~~The design live load is used for the local analysis of structural elements and members.~~ Consideration is given to the amplification of these accelerations due to local flexibility of structural elements and members. Construction loads are not included when determining seismic loads. Other temporary loads are evaluated for contributing to the seismic loads on a case-by-case basis.

Seismic loads from the three components of the earthquake are combined using the SRSS method or the 100-40-40 percent rule described in ASCE 4-98. The 100-40-40 combination is expressed mathematically as follows:

~~Where:~~

appropriate level cracking for the particular element under consideration. The amplified forces are also used in the design of the structural members that support the flexible element.

Section 3.8.3.6 describes methods used to confirm that concrete properties satisfy design requirements.

Seismic Structural Damping

Seismic analysis of RB internal structures uses the following SSE structural damping values recommended by RG 1.61.

Structure Type	Percent of Critical Damping
• Welded Steel	4
• Bolted Steel, Slip-Critical Connections	4
• Bolted Steel, Bearing Connections	7
• Reinforced Concrete	7

Hydrodynamic Load Analyses

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Hydrodynamic loads are applied to the IRWST and refueling canal walls and floors to account for the impulsive and impactive effects of water moving and sloshing in the tank as a result of seismic excitation. These loads are considered as part of the seismic SSE loads, and components of these loads in the three orthogonal directions are combined in the same manner as other seismic loads. Methodology consistent with ~~ASCE Standard 4-98 and~~ USAEC TID-~~702.4~~7024 is ~~are~~ used to determine hydrodynamic loadings. The effect of tank structure flexibility on spectral acceleration is included when determining the hydrodynamic pressure on the tank walls for the impulsive mode.

Design for hydrodynamic loads is within the elastic range of concrete and steel members and elements.

Polar Crane Seismic Analyses

Design of the RCB for seismic loads from the polar crane is performed with the crane in positions that result in maximum stresses on the supporting containment wall. See Section 3.8.1 for additional information on the design of the RCB.

For seismic load combinations, the polar crane design is based on the trolley being located in different positions along the bridge girders. Seismic evaluations are performed with and without the critical load raised to different positions for the trolley locations to determine which hook position produces the primary response of to these component supports in separate load cases to determine overall effects on the RB internal structures (GDC 4 and GDC 50). Worst-case accident pipe reaction loads are further evaluated in local designs of the component supports in the critical sections described in Appendix 3E. Concrete and steel members are designed to accommodate accident pipe reaction loads within the elastic range of their section strength.

Pipe break reaction, jet impingement, and missile loads (R_{rr}, R_{rj}, R_{rm}) are not applied to the overall ANSYS computer model because they do not result in global loadings on the RB internal structures. These loads are considered in local design of concrete walls and floors and steel members. As defined in Section 3.8.3.3.1 under the definitions of abnormal loads, dynamic load factors are applied when analyzing structures for the static equivalent of these loads. Elasto-plastic behavior may be assumed with appropriate ductility ratios, provided that excessive deflections do not result in the loss of function of any safety-related SSC. Appendix C of ACI 349-2001 is used to determine pipe break reactions, jet impingement, and missile impact impulsive and impactive loads. The design of the RB internal structures for these loads conforms to the procedures described in Section 3.5 for internally generated missiles. Section 3.5 also describes ductility limits that are met for impactive and impulsive loadings.

Local flood loads (F_a) are applied to walls and floors of the RB internal structures in the overall ANSYS computer model. Concrete and steel members are designed to accommodate these flood loads within the elastic range of their section strength.

3.8.3.4.5 Design Report

Design information and criteria for Seismic Category I structures are provided in Sections 2.0, 2.4, 2.5, 3.3, 3.5, 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5. Design results are presented in Appendix 3E for Seismic Category I structure critical sections.

3.8.3.5 Structural Acceptance Criteria

Limits for allowable stresses, strains, deformations, and other design criteria for reinforced concrete RB internal structures are in accordance with ACI 349-2001, and its appendices, including the exceptions specified in RG 1.142, with the exception that
03.08.03-20 the shear strength reduction factor of 0.85 is used as allowed in ~~ACI 349-2006~~ACI 349-06 . The exceptions specified in RG 1.142 (GDC 1, GDC 2, GDC 4 and GDC 50) are considered.

Limits for allowable loads on concrete embedments and anchors are in accordance with ~~Appendix B of ACI 349-2006~~ACI 349-06 (Appendix D with exceptions stated in Section 3.8.1.2.1, "Codes") and guidance given in RG 1.199.

Limits for the allowable stresses, strains, deformations and other design criteria for structural steel RB internal structures are in accordance with ANSI/AISC N690-1994, including Supplement 2 (GDC 1, GDC 2, GDC 4 and GDC 50).

3.8.4.2.1 Codes and Standards

- ACI 301-05 - Specifications for Structural Concrete for Buildings.
- ACI 304R-00 - Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- ACI 305.1-06 - Hot-Weather Concreting.
- ACI 306R-88 (Re-approved 2002) - Cold-Weather Concreting.
- ACI 306.1-90 (Re-approved 2002) - Standard Specification for Cold Weather Concreting.
- ACI 308R-01 - Guide to Curing Concrete.
- ACI 308.1-98 - Standard Specification for Curing Concrete.
- ACI 311.4R-05 - Guide for Concrete Inspection (Reference 40).
- ACI 347-04 - Guide to Formwork for Concrete.
- ACI 349-01/349-R01 - Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary on Code Requirements for Nuclear Safety Related Concrete Structures (exception described in 3.8.4.4 and 3.8.4.5) (GDC 1).
- ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D) with the exception of Condition A strength reduction factors even when supplemental reinforcement is provided (Reference 63).

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- ACI 349.1R-07 - Reinforced Concrete Design for Thermal Effects on Nuclear Power Plant Structures.
- ACI 350-06 - Code Requirements for Environmental Engineering Concrete Structure (Reference 58).
- ACI 350.3-06 - Seismic Design of Liquid-Containing Concrete Structures (Reference 59).
- AISC 303-~~05~~00 - Code of Standard Practice for Steel Buildings and Bridges.
- ANSI/AISC N690-1994 - Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities, including Supplement 2 (2004) (GDC 1).
- ~~ANSI/AISC 341-05 - Seismic Provisions for Structural Steel Buildings, American Institute of Steel Construction, including Supplement 1.~~
- ANSI/ANS-6.4-2006 - Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants (Reference 4).

- Expansion anchors.
- Cranes and hoists.

3.8.4.2.3 Design Criteria

- ACI 349-01/349-R01 - Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary on Code Requirements for Nuclear Safety Related Concrete Structures (GDC 1).
- ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D) with the exception of Condition A strength reduction factors even when supplemental reinforcement is provided (Reference 63).

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- ANSI/AISC N690-1994 - Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities, including Supplement 2 (2004) (GDC 1).

3.8.4.2.4 Regulations

- 10 CFR 50, Appendix A - General Design Criteria for Nuclear Power Plants, GDC 1, GDC 2, GDC 4, and GDC 5.
- 10 CFR 50, Appendix B - Quality Assurance Criteria for Nuclear Power Plants and Fuel Processing Plants."
- 10 CFR 50, Appendix S - Earthquake Engineering Criteria for Nuclear Power Plants.

3.8.4.2.5 NRC Regulatory Guides

Regulatory Guides applicable to the design and construction of other Seismic Category I structures:

- RG 1.61, Revision 1, March 2007 (exception described in 3.7.1).
- RG 1.69, December 1973.
- RG 1.115, Revision 1, July 1977.
- RG 1.142, Revision 2, November 2001 (exception described in 3.8.3.3).
- RG 1.160, Revision 2, March 1997.
- RG 1.199, November 2003.

- 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 tornado-generated missiles—The 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.

3.8.4.3.2 Loading Combinations

Load combinations for design of other Seismic Category I structures are in accordance with ACI 349-2001 and RG 1.142, Revision 2, November 2001 for concrete structures, and in accordance with ANSI/AISC N690-1994 including Supplement 2 (2004) for steel structures (GDC 1, GDC 2, GDC 4, and GDC 5).

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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 ACI 349-2001 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

Design and analysis procedures described in the following sections also apply to the design of supports for Seismic Category I distribution systems (i.e., pipe supports, 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.

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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, with the exceptions that the shear strength reduction factor of 0.85 is used as allowed in ACI 349-2006. Use of this shear strength reduction factor is acceptable because the loss of strength and stiffness due to cyclic inelastic loading in structural members of nuclear structures is smaller when compared to that of a conventional building structure, where a lower reduction factor is used. 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 ~~Appendix B of~~ ACI 349-~~2001~~06 (Appendix D with exceptions stated in Section 3.8.1.2.1, "Codes") and RG 1.199. Ductility is provided by designing anchorage systems such that a steel failure mode controls the design. 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 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-~~04~~00/~~2004~~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.

static normal load concrete and service load steel loading combinations. Concrete and steel members are designed to accommodate these static loads within the elastic range of their section strength. For concrete structures, uncracked section properties are used to proportion loadings to members. However ultimate strength design is used to reinforce concrete elements and members subjected to the normal factored loading combinations defined in Section 3.8.4.3.2.

Static fluid pressure loads are considered for design of the walls and floors of tanks and storage pools. Moving loads are considered for mobile plant equipment (e.g., cranes, hoists, truck bays in buildings, maintenance aisles).

Seismic and Other Dynamic Analyses and Design

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Seismic analyses and designs of other Seismic Category I structures conform to the procedures described in Section 3.7.2. The requirements of ASCE 4-98, as applicable to the 100-40-40 percent rule, are used in the analysis and design of structural elements and members subjected to load combinations that include seismic loadings. Seismic accelerations are determined from structural stick models as described in Section 3.7.2. These accelerations are applied to the finite element computer models of other Seismic Category I structures as static-equivalent loads at the elevations used in the stick model. Seismic acceleration modification factors are used to adjust the equivalent static forces and moments to be consistent with the SSI model results.

Seismic SSE (E') loads are obtained by multiplying the dead load and 25 percent of the design live load by the structural accelerations obtained from the seismic analyses of each structure. A minimum of 75 percent of the roof snow load is included in the structural mass for seismic analysis of Seismic Category I structures. Seismic loads are also considered due to the mass of fluids in tanks and canals as described below for hydrodynamic loads. ~~The full potential live load, including precipitation, is used for the local analysis of structural elements and members.~~ Consideration is given to the amplification of seismic accelerations obtained from the structural stick model of each structure, due to local flexibility of structural elements and members. Construction loads are not included when determining seismic loads. Other temporary loads are evaluated for contributing to the seismic loads on a case-by-case basis.

~~Seismic loads from the three components of the earthquake motion are combined using the SRSS method or the 100-40-40 percent rule described in ASCE 4-98. The 100-40-40 combination is expressed mathematically as follows:~~

~~Where:~~

~~R = the reaction force or moment that is applied in the three orthogonal directions x, y, and z:~~

~~$R = (\pm 1.0R_X \pm 0.4R_Y \pm 0.4R_Z)$~~

modified by cracked-section analysis using analytical techniques, when the state of loading indicates the development of cracks.

The effect of local wall and floor slab flexibility is included where the analysis indicates the existence of this condition. The concrete section properties used in calculating the amplified seismic forces include an appropriate level cracking for the particular element under consideration. The amplified forces are also used in the design of the structural members that support the flexible element.

Section 3.8.4.6 describes methods used to confirm that concrete properties satisfy design requirements.

Seismic Structural Damping

Seismic analysis of other Seismic Category I structures uses the following SSE structural damping values as recommended by RG 1.61.

Structure Type	Percent of Critical Damping
• Welded Steel	4
• Bolted Steel, Slip Critical Connections	4
• Bolted Steel, Bearing Connections	7
• Reinforced Concrete	7

Hydrodynamic Loads

Hydrodynamic loads are applied to the walls and floors of the spent fuel pool and liquid storage tanks in the SBs and in the ESWBs to account for the impulsive and impactive effects of the water moving and sloshing in the tanks as a result of seismic excitation. These loads are considered as part of the seismic SSE loads, and components of these loads in the three orthogonal directions are combined in the same manner as other seismic loads. The requirements of ~~ASCE 4-98, "Seismic Analysis of Safety-Related Nuclear Structures,"~~ ASCE Manual No. 58, USAEC TID-7024, and other proven methods are used to determine hydrodynamic loadings. The effect of tank structure flexibility on spectral acceleration is included when determining the hydrodynamic pressure on the tank wall for the impulsive mode.

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Design for hydrodynamic loads is within the elastic range of concrete and steel members and elements.

Thermal Analysis and Design

Normal thermal loads (T_o) are considered in the analysis and design of other Seismic Category I structures. Abnormal pipe break accident thermal loads (T_a) are considered

In addition to structural dead loads, slab live loads, piping loads and equipment loads, the GT STRUDL finite element model 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.

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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., 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 22 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. Impact factors will be applied to live loads as appropriate. Where buried items are vulnerable to highway or railway traffic loads, A COL applicant that references the U.S. EPR design certification will describe the design and analysis procedures used for buried conduit and duct banks, and buried pipe and pipe ducts.

A COL applicant that references the U.S. EPR design certification will use results from site-specific investigations to determine the routing of buried pipe and pipe ducts.

A COL applicant that references the U.S. EPR design certification will perform geotechnical engineering analyses to determine if the surface load will cause lateral or vertical displacement of bearing soil for the buried pipe and pipe ducts and consider the effect of wide or extra heavy loads.

3.8.4.4.6 Design Report

Design information and criteria for Seismic Category I structures are provided in Sections 2.0, 2.4, 2.5, 3.3, 3.5, 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5. Design results are presented in Appendix 3E for Seismic Category I structure critical sections.

3.8.4.5 Structural Acceptance Criteria

Limits for allowable stresses, strains, deformations and other design criteria for other Seismic Category I reinforced concrete structures are in accordance with ACI 349-2001 and its appendices, with the exceptions that the shear strength reduction factor of

03.08.03-20 0.85 is used as allowed in ACI 349-~~20~~06. (GDC 1, GDC 2, and GDC 4). Limits for concrete design include the exceptions specified in RG 1.142.

Limits for allowable loads on concrete embedments and anchors are in accordance with the requirements of ~~Appendix B of~~ ACI 349-~~2001~~06 (Appendix D with exceptions stated in Section 3.8.1.2.1, "Codes") and RG 1.199.

Limits for the allowable stresses, strains, deformations, and other design criteria for other structural steel Seismic Category I structures are in accordance with ANSI/AISC N690-1994 (R2004) including Supplement 2 (GDC 1, GDC 2, and GDC 4).

Allowable settlements for other Seismic Category I structures are described in Section 2.5.

The design of other Seismic Category I structures is generally controlled by load combinations containing SSE seismic loads. Stresses and strains are within the ACI 349-2001 limits, with the exceptions previously listed, and ANSI/AISC N690-1994 limits.

Appendix 3E provides design results for critical sections of other Seismic Category I structures.

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provide support and anchorage for the RCB is the area under the circumference of the outer face of the RSB wall, as shown on Figure 3.8-11, Figure 3.8-12, ~~and~~ Figure 3.8-13, and Figure 3.8-118. This portion of the NI Common Basemat Structure foundation basemat is designed in accordance with the ASME BPV Code 2004 Edition, Section III, Division 2. A circular gallery is provided beneath the NI Common Basemat Structure foundation basemat for maintenance access to the bottom of the vertical post-tensioning tendons provided in the RCB shell wall. The tendon access gallery is approximately 11 feet wide by 14 feet high, including an approximately 36 inch thick foundation slab under the gallery structure. No credit is taken in the design for the tendon gallery transmitting vertical loads into the soil ~~in vertical or horizontal bearing. C~~,and the connection of the tendon gallery to the NI Common Basemat Structure foundation ~~basement~~basemat allows for differential movement between the concrete structures. However, the tendon gallery acts as a shear key and transfers lateral loads into the basemat.

Sections 3.8.1 and 3.8.3 describe the interface of the RCB containment liner plate and upper internal basemat above the liner for supporting the RB internal structures. Sections 3.8.4 describes the interface of the RSB, FB, and SBs with the NI Common Basemat Structure foundation basemat. Concrete walls and columns of these NI Common Basemat Structure Seismic Category I structures are anchored into the NI Common Basemat Structure foundation basemat with reinforcing bars to transmit vertical, horizontal, and bending moment loads into the basemat and to enhance the rigidity of the basemat.

Horizontal shear loads are transferred from the NI Common Basemat Structure foundation basemat to the underlying soil by friction between the bottom of the basemat, mud mat (or both), and the soil, and by passive earth pressure on the below-grade walls of the NI Common Basemat Structure Seismic Category I structures and tendon gallery are analyzed to act as shear keys~~; shear keys are not used~~. Section 2.5.4.2 describes the friction coefficient properties of soil addressed for the U.S. EPR.

Buildings adjacent to the NI Common Basemat Structure are separated from the NI Common Basemat Structure foundation basemat to allow for differential seismic movements between buildings. Refer to Figure 3B-1, which illustrates the gaps between buildings.

Waterproofing membranes used under or within the NI Common Basemat Structure foundation basemat will be evaluated on a site-specific basis, as described in Section 3.8.5.6.

In addition, the portion of the NI Common Basemat Structure foundation basemat under the RCB/RSB is designed in accordance with the ASME BPV Code–2004 Edition, Section III, Division 2 for support and anchorage of the concrete RCB.

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3.8.5.3 Loads and Load Combinations

Loads and load combinations for Seismic Category I foundations are the same as those in Section 3.8.4.3.

In addition to the loads addressed in Section 3.8.4.3, the NI Common Basemat Structure foundation basemat is designed for the loads and load combinations from the RCB as described in Section 3.8.1.3. The NI Common Basemat Structure foundation 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 BPV Code–2004 Edition, Section III, Division 2 and RG 1.136 (Exception: RG 1.136 endorses the 2001 Edition of the ASME BPV 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 BPV Code, inclusive of the exceptions taken in RG 1.136).

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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, and tornados and against flotation due to floods:

Horizontal shears, such as those produced by wind, tornados, and earthquakes are transferred to the subgrade by friction along the bottom of the foundation basemat, shear key, or by passive earth pressure (or both). Waterproofing membranes used under or within the Seismic Category I foundations will be evaluated on a site-specific basis, as described in Section 3.8.5.6.

Design and analysis procedures for Seismic Category I foundations are the same as those described in Sections 3.8.1.4 and 3.8.4.4 for the respective structures that apply loads on the foundations.

Seismic Category I concrete foundations are designed in accordance with ACI 349-01 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 3.8.5.3. In addition, the portion of the NI Common Basemat
03.08.01-38 Structure foundation basemat that supports the RCB/RSB is designed in accordance with the ASME BPV Code–2004 Edition, Section III, Division 2 for support and anchorage of the concrete RCB as described in Section 3.8.1.

The design of concrete foundations for Seismic Category I structures is performed using the strength-design methods described in ACI 349-01, with the exception that a
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Foundation design is performed for the spectrum of soil cases described in Section 3.7.1. Section 2.5 and Section 3.7 describe seismic parameters and design methods used for analyzing and designing Seismic Category I structures.

Soil-structure interaction and structure-soil-structure interaction effects are considered in the seismic analyses of Seismic Category I structures as described in Section 3.7.2. Figure 3B-1 illustrates separation distances between Seismic Category I structures upon which these interaction evaluations are based.

The NI Common Basemat Structure is designed for an average static soil bearing pressure of 14,500 pounds per square foot and a maximum static bearing pressure of 22,00034,560 pounds per square foot. 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:

- The one-third increase in allowable stresses for concrete and steel members due to seismic (E') or wind (W and W_t) loadings is not permitted.

In addition, dynamic soil pressure and passive earth pressure have been considered for the below-grade walls, reflecting the total embedment depth of nominally 22 feet.

Similar to the approach for the EPGB, the foundation basemat is analyzed and designed using the GT STRUDL v.29.1 finite element analysis code. The finite element model contains both the building superstructure (i.e., reinforced concrete walls, slabs, and beams) and the foundation basemat. Analysis of the ESWB includes all applicable design loads and design load combinations described in Section 3.8.4.3. Figure 3.8-105—Essential Service Water Building Foundation Basemat Model illustrates the foundation basemat portion of the overall ESWB finite element model.

The GT STRUDL finite element model representing the ESWB foundation basemat consists of SBHQ6 rectangular elements, each with six degrees of freedom. This element type is capable of capturing both in-plane and out-of-plane behavior. Elastic boundary conditions are included in the finite element model in order to simulate the stiffness of the supporting soil. Basemat flexibility and SSI are addressed by inclusion of the basemat section properties and aforementioned soil spring boundary conditions in the finite element model. Illustrations of the complete finite element model representing the ESWB are provided in Section 3.7.2.

Detailed analysis and design procedures are described in the critical sections presented in Appendix 3E for the ESWBs.

3.8.5.4.5 Design Report

Design information and criteria for Seismic Category I structures are provided in Sections 2.0, 2.4, 2.5, 3.3, 3.5, 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5. Design results are presented in Appendix 3E for Seismic Category I structure critical sections.

3.8.5.5 Structural Acceptance Criteria

Limits for allowable stresses, strains, deformations, and other design criteria for Seismic Category I concrete foundations are in accordance with ACI 349-01 and its appendices, with the exception that the shear reduction factor of 0.85 is used as allowed in ACI 349-06 (GDC 1, GDC 2 and GDC 4). Limits for concrete design include the exceptions specified in RG 1.142. In addition, the portion of the NI Common

03.08.01-38 Basemat Structure foundation basemat that supports the RCB/RSB is in accordance with the ASME BPV Code and RG 1.1.36 for containment loadings as described in Section 3.8.1.

Limits for the allowable stresses, strains, deformations, and other design criteria for structural steel elements of Seismic Category I foundations are in accordance with ANSI/AISC N690-1994 (R2004), including Supplement 2 (GDC 1, GDC 2 and GDC 4).

The design of Seismic Category I foundations is generally controlled by load combinations containing SSE seismic loads. Stresses and strains are within the ACI 349-01 limits, with the exceptions previously listed. Limits for allowable loads on concrete embedments and anchors are in accordance with Appendix BD of ACI 349-2006 (with exceptions stated in Section 3.8.1.2.1, Codes) and guidance given in RG 1.199. Portions of the NI Common Basemat Structure foundation basemat that support the RCB/RSB are within the limits in accordance with ASME BPV Code, Section III, Division 2.

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Seismic Category I foundations are required to satisfy the factors of safety against overturning, sliding, and flotation defined in Table 3.8-11. The calculated minimum factors of safety for the NI Common Basemat Structure are provided in Table 3.8-12—Minimum Factors of Safety Against Overturning, Sliding, and Flotation for Foundations – NI Common Basemat Structure. For the load combination containing seismic loads, the calculated minimum factors of safety are less than the values provided in NUREG-0800, for overturning and sliding of the NI Common Basemat Structure. The acceptability of these calculated values is further addressed in the following section for the NI Common Basemat Structure foundation basemat.

Acceptance criteria for soil conditions for the media supporting Seismic Category I foundations are addressed in Section 2.5.

Acceptance criteria for settlement for Seismic Category I foundations are addressed in Section 2.5.

Additional acceptance criteria for critical areas of these structures are described in Appendix 3E.

An as-built report is prepared to summarize deviations from the approved design and confirm that the as-built Seismic Category I foundations are capable of withstanding the design basis loads described in Section 3.8.5.3 without loss of structural integrity or safety-related functions.

A COL applicant that references the U.S. EPR design certification will evaluate site-specific methods for shear transfer between the foundation basemats and underlying soil for soil parameters that are not within the envelope specified in Section 2.5.4.2.

3.8.5.5.1 Nuclear Island Common Basemat Structure Foundation Basemat

Appendix 3E provides details of the design of the NI Common Basemat Structure foundation basemat critical areas.

Maximum soil bearing pressures under the NI Common Basemat Structure foundation basemat are 22,000 pounds per square foot for static loading conditions, and 34,56026,000 pounds per square foot for dynamic loading conditions.

loading conditions. The factors of safety against overturning, sliding, and flotation are each greater than or equal to 1.1.

3.8.5.6 Materials, Quality Control, and Special Construction Techniques

This section contains information relating to the materials, quality control programs and special construction techniques used in the fabrication and construction of Seismic Category I foundations.

3.8.5.6.1 Materials

Concrete, reinforcing steel, and structural steel materials for Seismic Category I foundations have been used in other nuclear facilities and are the same as described in Section 3.8.3.6 (GDC 1), except as follows:

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- Materials for the portion of the foundation basemat that supports the RCB/RSB are the same as described in Section 3.8.1.6.
- Structural concrete used in the construction of Seismic Category I foundations has a minimum compressive strength of 4000 psi (f'_c) at 90 days.
- Epoxy coated reinforcing steel will be considered, on a site-specific basis, for use in foundations when groundwater may adversely affect the long-term durability of the concrete foundation. This may be waived if the groundwater level is below the foundation level due to either natural site conditions or provision of a site-specific permanent dewatering system. For epoxy coated reinforcing steel, the required splice length is increased in accordance with ACI 349-01 specifications.
- Use of waterproofing membrane, a textured geo-synthetic material, will be considered on a site-specific basis for use around foundations on sites with a high water table. Where this material is used under Seismic Category I foundations it will be embedded within the mud mat as shown in Figure 3.8-117—Geosynthetic Water Proofing Membrane.

The textured waterproofing membrane will provide adequate frictional characteristics, m>0.7, at its interface with concrete. This characteristic will be demonstrated by vendor testing. The contact surface between the membrane and the concrete will be finished in accordance with manufacturer recommendations. The membrane is not a safety-related component as its failure would not result in core melt or a release of radioactivity to the environment.

A COL applicant that references the U.S. EPR design certification will evaluate and identify the need for the use of waterproofing membranes and epoxy coated rebar based on site-specific groundwater conditions.

3.8.5.6.2 Quality Control

Quality control procedures for Seismic Category I foundations are the same as described in Section 3.8.3.6 (GDC 1).

3.8.5.6.3 Special Construction Techniques

Seismic Category I foundations are constructed using proven methods common to heavy industrial construction. No special, new, or unique construction techniques are used.

Modular construction methods are used to the extent practical for prefabricating portions of reinforcing and concrete formwork. Such methods have been used extensively in the construction industry. Rigging is pre-engineered for heavy lifts of modular sections.

3.8.5.7 Testing and Inservice Inspection Requirements

Monitoring and maintenance of Seismic Category I foundations is performed in accordance with 10 CFR 50.65 and supplemented with the guidance inof RG 1.160 (GDC 1).

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Additional testing and surveillance requirements for the portion of the foundation basemat that supports the RCB/RSB are the same as described in Section 3.8.1.7.2,.

Physical access is provided to perform inservice inspections of exposed portions of Seismic Category I foundations.

A COL applicant that references the U.S. EPR design certification will identify if any site-specific settlement monitoring requirements for Seismic Category I foundations are required based on site-specific soil conditions.

A COL applicant that references the U.S. EPR design certification will describe the program to examine inaccessible portions of below-grade concrete structures for degradation and monitoring of groundwater chemistry.

3.8.6 References

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2. SEI/ASCE 37-02, “Design Loads on Structures During Construction,” 2002, American Society of Civil Engineers, 2002.

3. NUREG-0800, Standard Review Plan, Section 3.8.1, “Concrete Containment,” Revision 2, March 2007.

54. ASTM 325-07, "Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength," American Society for Testing and Materials, 2007.

55. ASTM A490-06, "Standard Specification for Structural bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength," American Society for Testing and Materials, 2006.

56. ASTM A307-07, "Standard specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength," American Society for Testing and Materials, 2007.

57. Gazetas, George, "Foundation Vibrations," Chapter 15 in Foundation Engineering Handbook, 2nd Edition, edited by Hsai-Yang Fang, CBS Publishers, New Delhi, India, 1997.

58. ACI 350-06, "Code Requirements for Environmental Engineering Concrete Structure," American Concrete Institute, 2006.

59. ACI 350.3-06, "Seismic Design of Liquid-Containing Concrete Structures," American Concrete Institute, 2006.

60. ASME B31.3, "Process Piping, American Society of Mechanical Engineers," American Society of Mechanical Engineers, 1996.

61. ASME B31.4, "Liquid Transportation System for Hydrocarbon, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols," American Society of Mechanical Engineers, 1992.

62. ASME B31.8, "Gas Transportation and Distribution Piping Systems," American Society of Mechanical Engineers, 1995.

63. ACI 349-06/349R-06, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary (Appendix D).

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Figure 3.8-118—Jurisdictional Boundaries for the Design of Co