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MFN 06-298

Docket No. 52-010

August 31, 2006

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 38 Related to ESBWR Design Certification Application – Structural Analysis - RAI Numbers 3.8-1, 3.8-2, 3.8-4, 3.8-5, 3.8-7 through 3.8-12, 3.8-15, 3.8-16, 3.8-21, 3.8-22, 3.8-29 through 3.8-31, 3.8-39, 3.8-42, 3.8-43, 3.8-45, 3.8-50, 3.8-52 through 3.8-55, 3.8-57, 3.8-58, 3.8-60, 3.8-61, 3.8-66 through 3.8-68, 3.8-70 through 3.8-72, 3.8-74, 3.8-75, 3.8-78, and 3.8-98**

Enclosure 1 contains GE's response to the subject NRC RAIs transmitted via the Reference 1 letter. Please note that RAIs 3.8-38 and 3.8-44, which GE agreed to respond to by August 31, 2006, are not included. We request that these two RAI responses be deferred to the package that will be submitted by October 31, 2006.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

Enclosure:

1. MFN 06-298 - Response to Portion of NRC Request for Additional Information Letter No. 38 Related to ESBWR Design Certification Application – Structural Analysis - RAI Numbers 3.8-1, 3.8-2, 3.8-4, 3.8-5, 3.8-7 through 3.8-12, 3.8-15, 3.8-16, 3.8-21, 3.8-22, 3.8-29 through 3.8-31, 3.8-39, 3.8-42, 3.8-43, 3.8-45, 3.8-50, 3.8-52 through 3.8-55, 3.8-57, 3.8-58, 3.8-60, 3.8-61, 3.8-66 through 3.8-68, 3.8-70 through 3.8-72, 3.8-74, 3.8-75, 3.8-78, and 3.8-98

Reference:

1. MFN 06-197, Letter from U. S. Nuclear Regulatory Commission to Mr. David H. Hinds, *Request for Additional Information Letter No. 38 Related to ESBWR Design Certification Application,* June 23, 2006

cc:	WD Beckner	USNRC (w/o enclosures)
	AE Cubbage	USNRC (with enclosures)
	LA Dudes	USNRC (w/o enclosures)
	GB Stramback	GE/San Jose (with enclosures)
	eDRF	0000-0056-5643

ENCLOSURE 1

MFN 06-298

Response to Portion of NRC Request for

Additional Information Letter No. 38

Related to ESBWR Design Certification Application

Structural Analysis

RAI Numbers 3.8-1, 3.8-2, 3.8-4, 3.8-5, 3.8-7 through 3.8-12,

3.8-15, 3.8-16, 3.8-21, 3.8-22, 3.8-29 through 3.8-31, 3.8-39,

3.8-42, 3.8-43, 3.8-45, 3.8-50, 3.8-52 through 3.8-55, 3.8-57,

3.8-58, 3.8-60, 3.8-61, 3.8-66 through 3.8-68, 3.8-70 through 3.8-72,

3.8-74, 3.8-75, 3.8-78, and 3.8-98

NRC RAI 3.8-1

Revision 1 of the Tier 2 DCD, Section 3.8.1.7.3, provides information about inservice inspections of the containment components. It is understandable that the COL applicants will develop plans for preservice and inservice inspections. However, (1) the DCD should provide additional pre-operational inspection requirements (per IWE-2000) specifically pertinent to the ESBWR containment, and (2) the IWE-1220 exclusions cited in Section 3.8.1.7.3.2 of the DCD should be revisited to minimize the inaccessible areas in the containment. Also, because of the high radiation areas in the containment, the remote means of monitoring certain structures and components inside the containments should be part of the DCD.

GE Response

(1) The requirements for performing the preservice inspection (PSI) per IWE-2000 are addressed in DCD Section 3.8.1.7.3.3, including pre-operational instruction to ensure PSI is performed after application of any required protective coating.

(2) The reference in DCD Section 3.8.1.7.3.2 to IWE-1220 discusses exclusions in general; the commitment to design to perform the required inspections per Subsection IWE is in the scope found in DCD Section 3.8.1.7.3.1. Provisions for access to specific areas for inspection are addressed in the detailed design, and discussion of remote tooling would only be included if for some design reason, the required inspections could not be carried out otherwise.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-2

Provide a basis for the seismic categorization of the following structures and servicing systems: (1) upper and lower drywell servicing hoists and cranes [Component U31 2 in Table 3.2-1], (2) Reactor Building Heating, Ventilation and Air Conditioning (HVAC) [Component U40], (3) Fuel building Structure [Component U97] and HVAC [Component U98], and (4) Control Building Structure [Component U73], I/II categorization. Also, discuss the basis for categorizing Intake Structure and Discharge Structures [Component W12] as "Not in Scope".

GE Response

(1) The seismic classification for the upper and lower drywell servicing hoists and cranes will be changed to seismic category I. DCD Table 3.2-1 will be revised in the next update as noted in the attached markup.

(2) Consistent with DCD Subsection 9.4.6.1, the Reactor Building HVAC (U40) portion of DCD Table 3.2-1 will be updated as shown in the attached markup to indicate that the isolation dampers and ducting penetrating the Reactor Building Boundary and associated controls that provide the isolation signal are safety-related and seismic category I. The remainder of the Reactor Building HVAC system is classified as seismic category II because it is required to maintain its structural integrity following a safe shutdown earthquake (SSE).

(3) The Fuel Building Structure (U97) is primarily classified as seismic category I to ensure it retains the capability to keep the spent fuel covered after an SSE. The HVAC penthouse, stair towers and elevator shafts are classified as seismic category II to ensure they remain intact following an SSE and thus won't jeopardize the safety-related function of the building. Thus, no change to DCD Table 3.2-1 is required for System U97.

Consistent with DCD Subsection 9.4.2.1, the Fuel Building HVAC (U98) portion of DCD Table 3.2-1 will be updated as shown in the attached markup to indicate that the isolation dampers and ducting penetrating the Fuel Building Boundary are safety-related and seismic category I. The remainder of the Fuel Building HVAC system is classified as seismic category II because it is required to maintain its structural integrity following a safe shutdown earthquake.

(4) The main control room and all safety-related control equipment are located below grade in the seismic category I portion of the Control Building Structure (U73). The above grade levels of the Control Building only contain nonsafety-related control equipment that is not required to function following an SSE.

Consequently, it is acceptable for the above grade portion of the Control Building to be classified as seismic category II. Thus, no change to DCD Table 3.2-1 is required for System U73.

The Intake Structure and Discharge Structures [Component W12] were listed as "Not in Scope" for the ESBWR Standard Plant because they are nonsafety-related structures that will vary in configuration on a site-specific basis. Nevertheless it is possible to define their classifications on a generic basis. The safety-related ultimate heat sink for ESBWR is the atmosphere, which receives heat via boiling of water in the IC/PCC and spent fuel pools. DCD Tier 2 Table 3.2 1 will be revised to provide classification information for these structures as well as for other systems that were listed as "Not in Scope".

DCD Table 3.2-1 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-4

Described how the jurisdictional boundaries defined in DCD Section 3.8.1.1.3 and Figure 3.8-1 meet the definition of jurisdictional boundaries as specified in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME BPVC), Division 2, Subsection CC. Subsection CC of the Code states that "When a structural concrete support is constructed as an integral part of the containment, it shall be included within the jurisdiction of these criteria." There are a number of structural components in the reactor building (RB), such as the RB concrete floor slabs, that are integrally connected to the containment structure that restrain and provide support to the containment under various loads (e.g., internal containment pressure).

GE Response

ASME III, Division 2, Subsection CC, Section CC-1140, require that the Containment conform to the requirements of ASME III, NCA-3254.2. Furthermore, Section CC-1140 states that NCA-3254.2 is supplemented by the provision below:

"When a structural concrete support is constructed as an integral part of the containment, it shall be included within the jurisdiction of these criteria."

According to the ASME Code Section III, NCA-3254.2, "Definition of Division 2 Boundaries", the support structure that is constructed as an integral part of the concrete containment shall be included within the jurisdiction of Division 2. However, in Interpretation No. 12 (III-2-83-01) of ASME Code Section III, the code committee states that when the containment mat is integral with other building foundations, only the portion of the containment foundation mat directly beneath the containment vessel including any additional peripheral volume for anchoring of the containment shell reinforcement shall be considered within the code jurisdictional boundary and constructed in accordance with the rules of ASME Code Section III Division 2. The portion of the common mat subject to the rules of ASME Section III, Division 2, shall be proportioned for the forces and moments resulting from the consideration of the entire mat. The loads from the portion of the common mat outside the rules of ASME Section III, Division 2, shall be specified in the design specification and applied to the ASME Section III Division 2 mat in combination with those specified for Section III, Division 2 mat. The load combinations specified in CC-3000 and the Design Specification shall be applicable for all loads.

The ESBWR containment pressure boundary, as described in DCD Section 3.8.1 is limited to the cylindrical walls of the containment, the foundation mat directly beneath the containment, and the top slab. This boundary is shown in DCD Figure 3.8-1. The fuel pool girders, RB floor slabs, cylindrical wall supporting the containment wall and suppression pool slab, and the diaphragm floor slab, which are outside of the boundary defined in DCD Figure 3.8-1, participate in carrying loads which act on the containment structure. The fuel pool girders, which are integral with the containment top slab, provide additional strength to resist internal containment pressure acting on the top slab. Similarly, the diaphragm floor slab and the RB floor slabs, which are integral with the containment wall, provide additional strength to resist internal containment pressure acting on the containment wall.

Analogous to the jurisdictional boundary definition per Interpretation No. 12, structural components (RB floor slabs, fuel pool girders etc.), which are integral with the containment are treated the same as the containment only as far as loads and loading combinations are concerned in the design. This is consistent with the USNRC's position shown in Regulatory Guide 1.142 (revision 2) on the design code (ANSI/ACI 349-97) and requirements for the diaphragm floor slab in the ABWR and Mark II design which is integral with the containment wall and participates in resisting a portion of the pressure load on the containment wall. See response to RAI 3.8-101 for additional information.

Interpretation No. 12 (III-2-83-01) of ASME Code Section III is below.

No DCD changes will be made in response to this RAI.

Interpretation: III-2-83-01

Subject: Section III, Division 2, CC-3200, Load Criteria Used for Containment Vessel and Auxiliary Building

Date Issued: September 9, 1982

File: NI81-180

Question (1): When a common foundation is used for both the containment vessel and auxiliary building in a nuclear power plant, is it permissible for only the volume of the common foundation directly beneath the Class CC containment vessel, including any additional peripheral volume for anchorage of the containment shell reinforcing, to be subject to the rules of Section III, Division 2?

Reply (1): The specific boundaries of a Section III, Division 2, Class CC containment vessel shall be specified in the Design Specification as required by NCA-3254.2. 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. The balance of the common foundation outside the jurisdictional boundary of the containment vessel, specified in the Design Specification, is not included in the scope of Section III, Division 2.

Question (2): If the balance of the common foundation is outside the scope of Section III, Division 2, what, if any, consideration should be given to the forces and moments of this portion of the foundation in the design of the Section III, Division 2 portion?

Reply (2): The portion of the common mat subject to the rules of Section III, Division 2, shall be proportioned for the forces and moments resulting from consideration of the entire mat. The loads from the portion of the common mat outside the rules of Section III, Division 2, shall be specified in the Design Specification and applied to the Section III, Division 2 mat in combination with those specified for the Section III, Division 2 mat. The load combinations specified in CC-3000 and the Design Specification shall be applicable for all loads.

NRC RAI 3.8-5

a) *DCD Section 3.8.1.2.2 and Table 3.8-9 indicate that ASME BPVC – 2004 is used for the design, fabrication, construction, testing, and in-service inspection of the concrete containment. The 2004 edition of the Code has not as yet been endorsed by the NRC; however, the 1989 edition was reviewed and accepted during the advanced boiling water reactor (ABWR) review process. Please provide a description of the differences between these two editions of the Code that are applicable to the design of the ESBWR containment (e.g., Subsections CC, NCA, and NE).*

b) *Assuming that the staff accepts the implementation of ASME Code 2004 edition for design of the ESBWR containment, the staff considers any deviation from the ASME Code 2004 edition for the design and construction of the containment would require NRC review and approval prior to implementation. This needs to be stated in Sections 3.8.1 and 3.8.2.*

c) *Since DCD Section 3.8.1.2.3 does not reference Regulatory Guide (RG) 1.94 (item 29 in Table 3.8-9), provide a discussion of how the provision of ANSI N45.2.5 and RG 1.94 are incorporated in the referenced codes and standards.*

GE Response

a) The differences between 1989 edition and 2004 edition (including the addenda after 1989 edition) of the ASME Section III Code for Subsections CC, NCA, and NE are summarized in two tables. One table presents the reduction in requirements due to the change from 1989 edition to the editions after 1989, while the other table presents the increase in requirements due to the change. When the requirements are reduced, a column called "Comments" at the end of the table summarizes those changes accepted by the USNRC and those that have not been endorsed. When the requirements are increased, the design is more conservative and meets 1989 edition requirements.

   The changes found in the table of reduction in requirements not endorsed by the USNRC, which are applicable to the ESBWR design, need NRC review and approval. They are:

   (1) Item III-1-A97 (96-250), Table NE-4622.7(b)-1, Exemption from PWHT

   (2) Item III-1-A95 (94-316), NE-3221.1(c)(1), Stress Intensity Values

   (3) Item III-2-A04, III-2 (BC03-472), CC-4331.2(b)(6) etc. (See Table), Cold Rolled Parallel Threaded Splices

   (4) Item III-2-A02 (BC01-698), CC-4542.1 and CC-4542.2, Back-up Bars

(5) Item III-2-A01 (2001 Edition, BC00-182), CC-4333.2.3 Splicing of Reinforcing Bars-Performance Tests

(6) Item III-2-A01 (2001 Edition, BC00-183), Table CC-4552-2 Postweld Heat Treatment Exemptions

(7) III-2-A01 (2001 Edition, BC00-357), CC-5531.2, Extent of Examination

(8) III-2-A95 (94-306), CC-4331.2(b)(5) etc. (See Table), Splicing of Reinforcing Bars

(9) III-2-A91 (91-212), CC-3421.4.1(c) etc. (See Table), Evaluation of Membrane Stress

(10) III-2-A91 (91-222), CC-4321.1(c), CC-4321.2, CC-4322(a), Bending of Reinforcing Bar

(11) III-2-A91, Table I-2.2, Material for Concrete Containment Vessel Liner -Remove limitations on the use of SA-738, Grade B

(12) III-2-A90 (89-332), CC-4321.2, Bending of Reinforcing Bar

(13) III-2-A90 (90-174), CC-4240(c), CC-4240(d), CC-4260, Cold Weather Concrete Placement

No DCD changes will be made in response to this item.

b) There are no deviations from ASME Code 2004 edition for the design and construction of the ESBWR containment; therefore, no revisions to the DCD are necessary in response to this item.

c) DCD Section 3.8.1.2.3 will be revised to include item 29 as well as 31 and 33 of DCD Table 3.8-9 in the next update as noted in the attached markup.

Table 3.8-5(1) Reductions in Requirements from 1989 Edition to 2004 Edition

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
III-1-A99 (BC98-563) (2/99)	NCA-1140(a)(2) Code Edition and Addenda Permitted for Construction	This revision permits the use of the latest Edition and Addenda endorsed by the regulatory authority having jurisdiction at the plant site at the time the construction permit application is docketed. This change incorporates the provisions of Case N-608, "Applicable Code Edition and Addenda, NCA-1140(a)(2), Section III, Division 1."	These provisions have been accepted by the USNRC, in its endorsement of the 1999 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A97 (97-200)	NCA-8320, NCA-8321, NCA-8322 Use of N-Symbol Stamp at Field Locations	This revision rewrites the paragraph to clarify the provisions by placing the requirements in two paragraphs. NCA-8322 addresses the application of the Stamp in the field without requiring extension of the Certificate of Authorization to the site, when only a pressure test is involved. The change also addresses subcontracting the pressure test.	These provisions have been accepted by the USNRC, in its endorsement of the 1999 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A04 (BC03-765)	NE-3352.2(b), NE-5280(b) Examination of Category B Butt Welds in Electrical Penetrations	This revision provides for the use of liquid penetrant examination or magnetic particle examination of root pass and the surface of the completed weld as an alternative to the radiographic examination requirements for Category B butt welds in electrical penetration assemblies. It also adds an allowable stress reduction factor and limits the base materials that can be used to P-No. 1 materials. The revision incorporates the provisions of Case N-505, "Alternative Rules for the Examination of Butt Welds Used as Closure Welds for Electrical Penetration Assemblies in Containment Structures, Section III, Division 1."	These provisions have been accepted by the USNRC, in Case N-505, in Regulatory Guide 1.84, Rev. 33.
III-1-A02 (BC00-771)	NE-2331, NE-2431, NE-4335 Impact Testing of Heat Affected Zone (HAZ)	Changes in steel making technology have enabled materials to be supplied with much better impact toughness properties than in the past. One problem associated with this is that it does not take much heat input to reduce the toughness of the HAZ to levels below the unaffected base material. This results in the need for more testing and test coupons. This revision allows three methods of qualifying the HAZ. 1) An upward adjustment of RT_{NDT}, which was the original basic method. 2) Downward adjustment in test temperature, which is currently permitted, but	These provisions have been accepted by the USNRC, in its endorsement of the 2002 Addenda of Section III, Subsections NB, NC, and ND

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		requires many tests for the development of the transition curves. This is difficult when using existing materials, without enough coupons. 3) Evaluation of actual material impact toughness test data with an adjustment upward of the toughness acceptance criteria to compensate for the loss of toughness shown on the Welding Procedure Specification (WPS). This can be used with existing material or new material. These changes include a 15F penalty without further test data. This alternative is based on many years of testing. An exemption is also provided for gas tungsten arc welding (GTAW) weld metal with a maximum of two layers for the HAZ.	
III-1-A02 (BC01-613)	Table NE-2121(a)-1 Addition of SA-738 Material	This revision permits the use of SA-738, Grade B material for construction of containment vessels. This material is a P-1, Group 3 ferritic material. The change incorporates the provisions of Case N-655, "Use of SA-738, Grade B for Metal Containment Vessels, Class MC, Section III, Division 1."	These provisions have been accepted by the USNRC, in its endorsement of the 2002 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A00	NE-4000 Standard Weld Procedure Specifications (SWPS)	Standard Weld Procedures Specifications were added to Section IX in the A00 Addenda. These SWPSs are acceptable for use in Section III by reference to Section IX. Highlights of the Section IX (QW-500) requirements are: 1) Not all AWS SWPSs are permitted. 2) A demonstration test coupon must be welded and tested; QW-520 lists specific information that must be recorded as part of the demonstration. 3) SWPSs must be used exactly as they are written; there are no "nonessential variables" when using SWPS. 4) The applicable fabrication document (i.e., construction code, customer specification, etc.) and the demonstration test number must be shown on the SPWS, and it must be signed and dated by the manufacturer or contractor.	These provisions have been accepted by the USNRC, in its endorsement of the 2000 Addenda of Section III, Subsections NB, NC, and ND.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
III-1-A99 (BC98-414) (12/98)	NE-3226, NE-6221 Test Limits	The purpose of this revision is to remove inconsistencies in the rules for testing. The change provides that a stress analysis for the test condition is not required unless the test pressure at some point in the vessel exceeds the required test pressure by more than six percent. For Class 1 components, the change reduces the pneumatic test pressure from 1.2 to 1.1 times the design pressure. The change also reduces the hydrostatic test pressure for Class 2 and 3 components from 1.5 to 1.25 times the design pressure, and the pneumatic test pressure from 1.25 to 1.1 times the design pressure. For Class MC containment vessels, the hydrostatic test pressure was reduced from 1.35 to 1.2 times the design pressure. These changes compensate for the reduction in design factor from 4 to 3.5 that was made to increase allowable stresses in Section II, Part D, Table 1A and Table 1B for Class 2 and 3 components. The pneumatic test pressure for containment vessels was not changed.	These provisions have been accepted by the USNRC, in its endorsement of the 1999 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A99 (BC98-571) (2/99)	NE-5279, NE-5280 Special Exemptions to Radiography	Previously these paragraphs provided rules for special exemptions to radiographic examination when weld joint details did not permit a meaningful examination. This revision changes the requirements to be consistent for all subsections. The effect of the change is to allow exceptions to radiography whenever radiographic examination is not practical.	These provisions have been accepted by the USNRC, in its endorsement of the 1999 Addenda of Section III, Subsections NB, NC, and ND.
II-D-A99 (BC98-165)	TABLE 1A, TABLE 1B STRESS TABLES Reduced Design Factor	This revision significantly increased all allowable stress values in these tables by reducing the design factor on tensile strength from 4 to 3.5. There was no change in the factor on yield strength, so not all allowable stresses are changed. The increase in allowable stress decreases as the design temperature increases. The increase in allowable stress is not dependent on any change in design formulas, nondestructive examination, or material properties. The main reason for the change is to be more consistent with the allowable stresses used in Europe and other parts of the world. The change will make the use of the ASME Code more competitive in the international market on an economical basis.	These provisions have been accepted by the USNRC, in its endorsement of the 1999 Addenda of Section III, Subsections NC and ND.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		This change incorporates the provisions of Case 2278, "Alternative Method for Calculating Maximum Allowable Stresses Based on a Factor of 3.5 on Tensile Strength, Section II and Section VIII, Division 1," Case 2290, "Alternative Maximum Allowable Stresses Based on the Factor of 3.5 on Tensile Strength, Section II, Part D, and Section VIII, Division 1," and Case 2284, "Alternative Maximum Allowable Stresses for Section I Construction Based on a Factor of 3.5 on Tensile Strength, Section I." To make this change, all of the Stress Tables were reviewed, and many changes were made to correct chemistry designations, product forms, external pressure chart references, heat treatments, and Notes. Also, many stress lines were merged. Changes to the Stress Tables, not directly associated with the change in the design factor used to determine allowable stresses, are identified with separate comments. In a number of places, the Summary of Changes printed with the Addenda identified materials as being deleted that were not. It only appeared that way because the stress lines were merged. The National Board of Boiler and Pressure Vessel Inspectors permits the use of the new allowable stresses for rerating pressure retaining equipment now in service that was produced to ASME Codes as far back as the 1968 Edition of the ASME Code. Provisions for doing this are given in National Board Interpretation 98-14. ERROR: Appendix 1, 1-100(a)(1), 1-100(a)(2), and Table 1-100 should have been revised to show the change in the design factors. Corrected by Special Notice.	
III-1-A97 (96-250)	Table NE-4622.7(b)-1 Exemptions to Mandatory Postweld	This change allows an exemption from postweld heat treatment for welds attaching nozzles and penetrations up to and including NPS 12.	The exemption is limited to P-No. 1 material; the shell and nozzle thickness do not exceed 1-1/2 in.; the preheat and carbon

Affecting Addenda after 1989 Ed.	Affected chapters	**REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels**	Comments
	Heat Treatment		content limits are identical to the limits for exemption of other welds in P-No. 1 materials; and nozzle diameter is irrelevant to the need for PWHT.
III-1-A95 (94-305)	NE-7726 Proration of Valve Capacity	This revision provides for proration of valve capacities to pressures greater than the pressure to which the valve capacity was certified.	These provisions have been accepted by the USNRC, in its endorsement of the 1995 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A95 (94-316)	NE-3221.1(c)(1) Stress Intensity Values	This change allows, under limited conditions, an increase in the primary membrane stress for Service Level D Limits, up to the maximum value permitted for Service Level C Limits.	This is a small increase in allowable stress and is limited to no more than the allowable stress for Service Level C Limits, which are otherwise generally lower than the allowable stress for Service Level D Limits.
III-1-A93	NE-2545.3(b), NE-2545.3(b)(3), NE-2545.3(b)(4), NE-2546.3(b), NE-2546.3(b)(3), NE-2546.3(b)(4) Acceptance Standards	This change clarifies the NDE acceptance criteria and provides consistency with NB-2576(c), NB-2677(c), NC-2576(c), NC-2677(c), ND-2576(c), ND-2677(c), NE-2576(c), NE-2677(c), NG-2576(c), and NG-2677(c). The significant change is to refer to only "relevant" indications.	These provisions have been accepted by the USNRC, in its endorsement of the 1987 Addenda of Section III, Subsections NB, NC, and ND.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
III-1-A92	NE-5112 Nondestructive Examination Procedures	This revision provides for the digitization of radiographic film and radioscopic images in accordance with the provisions of Section V, Article 2, Appendix III.	These provisions have been accepted by the USNRC, in its endorsement of the 1992 Addenda of Section III, Subsections NB, NC, and ND.
II-D-1992 Edition	TABLE 1A SECTION III-1, Class MC	Corrected Stress Values for SA-516 - 55 (K01800) from 15.1 ksi to 15.2 ksi.	The prior values were incorrect.
III-1-A91 (91-208)	NE-7512, NE-7721.3, NE-7724.2(a) Tolerances on Pressure Relief Valves	This revision increases the set pressure tolerances for pressure relief valves.	These provisions have been accepted by the USNRC, in its endorsement of the 1991 Addenda of Section III, Subsections NB, NC, and ND.
III-1-A90	NE-2510 Attachment Material	This revision deletes the requirement for examining the attached material in the same manner as the pressure retaining material to which it is welded. (TECHNICAL ERRATA to A87)	These provisions have been accepted by the USNRC, in its endorsement of the 1990 Addenda of Section III, Subsections NC and ND.
III-1-A90	Table NE-3132-1 Dimensional Standards	- Updated: ANSI B1.20.3-76 (R82) ANSI B16.5 to 88 This change extended nickel alloy ratings to higher temperatures, clarified flat face flange requirements, updated the referenced standards, and made other minor editorial revisions. Metric equivalents were deleted.	These provisions have been accepted by the USNRC, in its endorsement of the 1990 Addenda of Section III, Subsections NB, NC, and ND.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		ANSI B16.9 to 86 ANSI B16.11 to 80 ANSI B16.25 to 86 ANSI B16.28 to 86 ANSI B18.2.2 to 87 ANSI B18.3 to 86 ANSI B36.10 to 85 ANSI B36.19 to 85 ANSI B16.34 to 88 The scope of the standard was increased by the addition of socket welded end and threaded end valves. The listings for nickel alloy and other alloy valve materials were expanded. Also, rules for threaded body joints were added and wafer-type valve body rules were revised. MSS SP-43 to 82 (R86) MSS SP-44 to 85	
III-1-A90	Table I-10.1 Stress Tables for Class MC Ferritic Steels	- Added: SA-738 - C (to 2-1/2 in.) (TS/YS = 80/60) (2-1/2 in. to 4 in.) (TS/YS = 75/55) (4 to 6 in.) (TS/YS = 70/46) - Changed designation for: SA-738 - ... to SA-738 - A (K12447)	SA-738 Grade C has been accepted by the USNRC, in its endorsement of the 1990 Addenda of Section III, Subsections NC and ND (see Table I-7.1 for permitted materials for Class 2 and 3 applications).
III-2-A04, III-2 (BC03-472)	CC-4331.2(b)(6), CC-4333.2.3(a), CC-4333.2.3(b),	This revision adds cold rolled formed parallel threaded splices as an acceptable form of splice. Cold roll formed parallel threaded splices are being widely used in the construction industry. Cold rolled formed parallel threaded splices have a	This revision adds a new type of mechanical splice called a "cold-roll-formed parallel-threaded

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
	CC-4333.2.4(e)(3), CC-4333.2.4(g), CC-4333.3(b)(6), CC-4333.3(c)(4), CC-4333.3(d)(5), CC-4333.3(f), CC-4333.5.3(b) Cold Rolled Parallel Threaded Splices	special thread and locknut to lock the coupler. This mechanical splice is limited to cold formed parallel threaded splices to prevent any single threaded rebar from being included, which would not possess the extra cold rolling process. Requirements for locknuts, which need to be used on both ends of the device to prevent loosening and to improve slip performance, are included. A testing requirement for cold rolled parallel threaded splices at 20F is also required.	splice." This splice for reinforcing bars is widely used in the construction industry. The new coupler meets the current requirements for the "taper-threaded splices" to have threads, and the requirements of the "thread-deformed reinforcing bars," which require locknuts to lock the coupler. The new mechanical splice is limited to "cold-formed parallel-threaded splices," to prevent any single threaded re-bar from being included that would not possess the extra cold rolling process.
III-2-A02 (BC01-698)	CC-4542.1, CC-4542.2 Back-up Bars	This revision deletes the prohibition against the use of back-up bars in Category A and B welded joints.	For more than 70 years, Section VIII, Division 1 has permitted use of back-up bars for butt welds in the vessel shell. During this time, there has been no evidence of leakage caused by the back-up bars, even though they are subjected to the same stress as the pressure vessel shell. In Section III, Division 2, the containment liner plate is assumed to have no structural strength. It is logical to permit

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
			the same weld details in containment liners as permitted for pressure shells.
III-2-A01 (2001 Edition) (BC00-182)	CC-4333.2.3 Splicing of Reinforcing Bars-Performance Tests	This revision incorporates the provisions of Case N-363-1, "Splicing of Reinforcing Bars-Performance Tests, Section III, Division 2." The change permits acceptance of performance test results for reinforcing bar mechanical splices when the load extension does not achieve 2% strain. The alternative test results must meet the lesser of 2% strain or 125% of the specified minimum yield strength of the reinforcing bar.	The alternative test is more than adequate to assure the structural capability of the splices. (The USNRC has not endorsed Case N-363-1.)
III-2-A01 (2001 Edition) (BC00-183)	Table CC-4552-2 Postweld Heat Treatment Exemptions	This revision changes the Table to permit containment liners the same PWHT exemptions that were allowed for concrete reactor vessel liners. The change incorporates the provisions of Case N-536, "Alternative to Table CC-4552-2 Exemptions to Mandatory PWHT Concrete Containment Liner, Section III, Division 2."	There is no reduction in requirements when the alternative rules for containment liners are the same as for reactor liners. (The USNRC has not endorsed Case N-536.)
III-2-A01 (2001 Edition) (BC00-357)	CC-5531.2 Extent of Examination	This revision removes the requirement to increase number of radiographs of double-sided welds, when a portion of the liner uses backup bars and single-sided welding. This was an arbitrary requirement intended to discourage the use of single-sided welds with backup bars. The change also clarifies that the welds made using back-up bars shall be examined by UT or MT for the full length of the backed-up weld.	The number of radiographs has no effect on assuring acceptable weld quality.
III-2-A00 (BC00-005)	CC-2231.4 Specified Concrete Properties	This revision provides conditions under which the required creep testing of CC-2231.4, may be delayed. The change incorporates the provisions of Case N-529 "Creep Testing, Section III, Division 2."	It takes about 28 days for concrete to set. However, early in that time frame, it is possible to accurately evaluate the creep of the concrete based on early tests. This is common industry

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
			practice. Not applicable to the ESBWR RCCV. (The USNRC has not endorsed Case N-529.)
III-2-A00 (BC00-006)	CC-3543(a) Tendon Anchor Reinforcement	CC-3543(a) requires that reinforcement "be located starting not more than 2 inches from the bearing plate and not extending more than twice the minimum bearing plate width." This revision provides conditions under which that requirement can be waived. The change incorporates the provisions of Case N-488, "Design of Tendon and Anchorage Reinforcement, Section III, Division 2."	Not applicable to ESBWR.
III-2-A00 (BC00-007)	CC-4432.5 Twisting and Coiling Prestressing Tendons	This revision provides an alternative to the provisions of CC-4432.5 regarding intentional twisting for all horizontal circumferential tendons comprised of multiple elements. The change incorporates the provisions of Case N-487, "Twisting of Horizontal Prestressing Tendons, Section III, Division 2."	Not applicable to ESBWR
III-2-A96 (96-55)	CC-3740, CC-3750 Penetration Assemblies, Brackets and Attachments	Previously, Division 2 limited attachment loads in the through-thickness direction of plate. This revision eliminates that restriction and allows the full strength of the plate to be used in the through-thickness direction. This is a continuation of the similar change started in the 1995 Addenda.	Similar provisions in Section III, Division 1, Subsection NF have been permitted for Class 1, 2, and 3 supports by USNRC endorsement on the Winter 1982 Addenda.
III-2-A95 (94-309)	CC-3750(b), CC-4543.6, Fig. CC-4543.6-1, Fig. CC-4543.6-2 Through-Thickness Loads	The Code restricted allowable stresses in liners to one-half of the allowable stress for tensile loads normal to the liner, because of lamellar tearing, laminations, and through-thickness strength. Because of improved steel melting practices and examination techniques, the one-half factor has been eliminated. This revision provides new requirements that must be met when liner materials one inch and greater in thickness are loaded in the through-thickness direction. When loaded in this direction, the materials must meet the acceptance standards of SA-770, "Through-Thickness Tension Testing of Steel Plates for Special Applications." Special welding procedure qualifications are required, and must use either inlays or	Similar provisions in Section III, Division 1, Subsection NF have been permitted for Class 1, 2, and 3 supports by USNRC endorsement on the Winter 1982 Addenda.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		overlays, or special weld deposition techniques. After completion of welding, the base metal underneath the attachment weld must be ultrasonically examined. Special examination methods and acceptance standards are provided. This revision is similar to changes made to Section III, Division 1, Subsection NF in the Winter 1978 and Winter 1982 Addenda.	
III-2-A95 (94-306)	CC-4331.2(b)(5), CC-4333.2.3(a), CC-4333.2.4(f), CC-4333.3(e), CC-4333.4, CC-4333.5.3(a) Splicing of Reinforcing Bars	This revision adds provisions for a new mechanical reinforcing bar splice. The new splice is identified as a "sleeve with cementitious grout splice." The splice has been evaluated for use by building officials organizations and found to meet the requirements of ACI-318.	This splice has been in use for more than ten years and meets the requirements of ACI-318, which has served as the basis for the Section III, Division2 Concrete Code.
III-2-A93	CC-4532.2.1 Group Identification of Welders to Weld Joints	The revision allows multiple welds to have group identification for the purposes of verifying that all welders and welding operators were properly qualified. Previously, this group identification was only allowed for structural attachment welds. This revision incorporates the provisions of Case N-507, "Identification of Welders, Section III, Division 2."	The USNRC previously approved these provisions through endorsement of Case N-507 in RG 1.84, Rev. 32.
III-2-A92	Table CC-2160-1, Note (2), Codes, Standards, and Specifications Referenced in Text Dimensional Standards	This revision updates the listed standards and moves the dates to "Codes, Standards, and Specifications Referenced in Text." Pipes and Tubes - Updated: ASME B36.10 to M85 ASME B36.19 to M85	These provisions have been accepted by the USNRC, in its endorsement of various early-1990's Editions and Addenda of Section III, Subsections NB, NC, and ND. Most of the changes are editorial.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		Fittings, Flanges and Gaskets - Deleted: ANSI B70.1 Refrigeration Flare Type Fittings - Updated: ASME B16.5 to 88 Comments on the changes to this standard can be found in the RA-search data base Rev_B31. ASME B16.9 to 86 ASME B16.11 to 80 ASME B16.21 to 78 ASME B16.25 to 86 ASME B16.28 to 86 - Titles for Standards were changed to: ASME B16.5 Pipe Flanges and Flanged Fittings ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges AWWA C207 Standard for Steel Pipe Flanges for Waterworks Services Bolting - Titles for Standards were changed to: ASME B18.2.1 Square and Hex Bolts and Screws (Inch Series) Including Hex Cap Screws, and Lag Screws ASME B18.2.2 Square and Hex Nuts (Inch Series) ASME B18.3 Socket Cap, Shoulder, and Set Screws (Inch Series) - Updated: ASME B18.2.2 to 87 ASME B18.3 to 86 Threads - Updated: ASME B1.1a to 84	

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		- Changed Standard Numbers from: ANSI B2.1 to ASME B1.20.1-83 Pipe Threads, General Purpose (Inch) ANSI B2.2 to ASME B1.20.5-78 (R80) Gaging for Dryseal Pipe Threads (In.) Valves - Updated: ASME B16.34 to 88 Comments on the changes to this standard can be found in the RA-search data base Rev_B31. - Titles for Standards were changed to: ASME B16.34 Valves - Flanged, Threaded, and Welded End This revision corrects the title of the dimensional standards to ASME because they are no longer subject to approval by ANSI. This revision also deletes the revision year from Table CB-2160 and CC-2160 because the revision dates are now given in, "Codes, Standards, and Specifications Referenced in Text," located at the end of the book.	
III-2-A92	Codes, Standards, and Specifications Referenced in Text	- Deleted: ANSI B2.1 Pipe Threads (Except Dryseal) ANSI B2.2 Dryseal Pipe Threads ANSI B70.1-60 Refrigeration Flare Type Fittings - Added: ANSI B1.20.1-83 Pipe Threads (Except Dryseal) ANSI B1.20.5-78 (R80) Gaging for Dryseal Pipe Threads - Updated: ANSI B1.1 to ASME B1.1a-84	These provisions have been accepted by the USNRC, in its endorsement of various early-1990's Editions and Addenda of Section III, Subsections NB, NC, and ND. Most of the changes are editorial.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
		ANSI B16.5 to ASME B16.5-88 Comments on the changes to this standard can be found in the RA-search data base Rev_B31, and are available upon request. ANSI B16.9 to ASME B16.9-86 ANSI B16.11 to ASME B16.11-80 ANSI B16.20 to ASME B16.20 ANSI B16.21 to ASME B16.21 ANSI B16.25 to ASME B16.25-86 ANSI B16.28 to ASME B16.28-86 ANSI B16.34 to ASME B16.34-88 Comments on the changes to this standard can be found in the RA-search data base Rev_B31, and are available upon request. ANSI B18.2.1 to ASME B18.2.1 ANSI B18.2.2 to ASME B18.2.2-87 ANSI B18.3 to ASME B18.3-86 ANSI B36.10 to ASME B36.10M-85 ANSI B36.19 to ASME B36.19M-85	
III-2-A91 (91-212)	CC-3421.4.1(c), CC-3421.4.2, CC-3421.4.2(h) Evaluation of Membrane Stress	This revision modifies the definition of membrane stress to be at the centroid of the concrete section where the shear load is applied. Previously the definition described the stress at the extreme fiber of the section.	Use of the centroid of the section is a more accurate approach to determination of stress.
III-2-A91 (91-222)	CC-4321.1(c), CC-4321.2, CC-4322(a) Bending of Reinforcing Bar	This revision changes the rules for bending reinforcing bar to conform to the provisions of ACI 318-89. The change provides that the minimum diameter of the bend in the bar and the extension length are dependent on the diameter of the reinforcing bar being bent. This revision removes the change made in the 1990 Addenda.	This change is consistent with the provisions of ACI-318.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
III-2-A91	CC-5536.2 Leak Chase System	This revision allows leak chase channels to be tested by air using the "maintenance of pressure" method. The change incorporates the provisions of Case N-231, "Alternate Methods for Leak Detection in the Attachment Weld to Leak Chase Channels for Section III, Division 2, Class CC Construction."	The USNRC previously approved these provisions through endorsement of Case N-231 in RG 1.84, Rev. 32.
III-2-A91	Table I-2.2 Material for Concrete Containment Vessel Liners	- Added: SA-210 - C (K03501) SA-738 - B (K12447) and C - Deleted: SA-234 - WPA SA-376 - 316L (S31603) - Changed: SA-181 - ... to 60 (K03502) & 70 (K03502) SA-210 - ... to A-1 (K02707) SA-738 - ... to A (K12447)	SA-210 is not applicable to ESBWR. SA-738 Grade B has been accepted by the NRC with limitations, in their endorsement of Case N-655 in RG 1.84 Rev. 33. The limitations require compliance with SA-738 Supplementary Requirements S17 and S20. SA-738 Grade C has been accepted by the USNRC, in its endorsement of the 1990 Addenda of Section III, Subsections NC and ND (see Table I-7.1 for permitted materials for Class 2 and 3 applications).
III-2-A90	CC-2242.5, CC-2242.6 Use of Prepackaged	This change incorporates the provisions of Case N-384-1, "Use of Prepackaged General Purpose Cement Grouts, Epoxy Grouts, and Epoxy Bonding Materials, Section III, Division 2, Class CC." The Case permitted the use of prepackaged grouts and bonding materials in lieu of materials mixed at site.	The USNRC previously approved these provisions through endorsement of Case N-384-1 in RG 1.84, Rev. 32.

Affecting Addenda after 1989 Ed.	Affected chapters	REDUCTIONS IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels	Comments
	General Purpose Cement Grouts		
III-2-A90 (90-174)	CC-4240(c), CC-4240(d), CC-4260 Cold Weather Concrete Placement	This revision provides a definition for cold weather concrete placement and clarifies the requirements for these conditions. The revision changes the period of temperature control at the surface of the concrete from seven days to three days.	The only effect of this change is to allow slower curing of the concrete, if the temperature falls below 32F. The concrete will cure sufficiently in three days to prevent damage due to freezing.
III-2-A90 (89-332)	CC-4321.2 Bending of Reinforcing Bar	This revision adds a standard industry tolerance for bending reinforcing bars. The specified tolerance is one bar diameter.	This change is consistent with the provisions of ACI-318. Furthermore, this change was removed by the revision in the 1991 Addenda.

Table 3.8-5(2) Increases in Requirements from 1989 Edition to 2004 Edition

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, *for steel and concrete containment vessels*
III-1-1995 Edition (94-229)	NCA-4134.10 Reporting Independence of Inspectors	This paragraph references NQA-1, Supplement 10S-1, for inspection. Paragraph 2.1 of the Supplement provides that inspection personnel shall not report directly to the immediate supervisors who are responsible for performing the work being inspected. This revision deletes the provisions of Paragraph 2.1, Personnel, for Section III work because such restrictions were felt unnecessary with the other controls already in NQA-1. (ERROR: The revision also deleted the provisions of Paragraph 2.2, Qualification. However, the provisions of Paragraph 2.2 are intended to be applicable to qualification of inspection personnel. Corrected A96.) (ERROR: The A94 Addenda now refers to the 1992 Addenda to NQA-1, which renumbered Paragraph 2.1, Personnel, as paragraph 3.1. Therefore this change should refer to the deletion of Paragraph 3.1 of NQA-1. Corrected A96.)
III-1-A94 (93-380)	NCA-3800, NCA-3810, NCA-3820, NCA-3830, NCA-3840, NCA-3841, NCA-3842, NCA-3850, NCA-3851, NCA-3852, NCA-3853, NCA-3855, NCA-3856, NCA-3857, NCA-3858, NCA-3859, NCA-3860, NCA-3861, NCA-3862	This revision modifies the quality assurance requirements for organizations providing metallic material. The terms “Material Manufacturer” and “Material Supplier” have been changed to “Material Organization.” The purpose of the change is allow any material organization to perform the work activities detailed in their Quality Assurance Program rather than to limit work activities based on whether the organization is considered a material manufacturer or a material supplier. This change is significant because it will require most organizations furnishing material under the provisions of NCA-3800 to extensively modify their QA Manual prior to their next ASME Survey. The revision adds or revises definitions for approved supplier, material, performance assessment, Quality System Program, source material, supplier, and unqualified source material. NCA-3842.2(h)(3) was added to permit annual performance assessments of qualified Material Organizations in lieu of annual audits. The performance assessments are to include evaluation of sample testing of furnished material to assure conformance with the material specification, along with evaluation of nonconformances and corrective actions. The old paragraph NCA-3867.4(e), which identified the rules for upgrading material, has been renumbered NCA-3855.5(a). “Stock material” is now identified as “unqualified source material.” NCA-3855.5(a)(1) clarifies that the restriction, “no welding,” on an unqualified source material means no

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
	Material Quality System Programs	welding with filler material added. Autogenous welding is exempt from this restriction. This revision deleted the exemption that allowed allows bars with a cross-sectional area of one square inch and less to be furnished with a Certificate of Compliance in lieu of a Certified Material Test Report. (ERROR: Not corrected.)
III-1-A93	NCA-3220(d), NCA-3220(n), NCA-3220(s), NCA-3270, NCA-3271, NCA-3272, NCA-3273, NCA-3280, NCA-3290 Overpressure Protection Report	This revision adds new provisions regarding the Owner's responsibilities for providing, certifying, and filing Class 1, 2, 3, and MC Overpressure Protection Reports. Other than the changes to the NCA-3270 paragraphs, the revision corrects references and renumbers paragraphs.
III-1-A92	NCA-5121(a) Authorized Inspection Agency	This revision requires that Authorized Inspection Agencies are to be accredited by ASME, not States nor Provinces.
III-1-A91	NCA-4110(b) Quality Assurance Program Requirements	This revision updates the reference to NQA-1 to the 1989 Edition, including the NQA-1a-1989 Addenda. The change also includes NQA-1a-1986 Addenda, NQA-1b-1987 Addenda, and NQA-1c-1988 Addenda. The following changes were included in the NQA-1a-1989 Addenda: 3S-1 - 5 Design Control Change Control *- Adds additional provisions for incorporating design changes into the appropriate design documents.*

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
		3A-1 Design Control - Rewritten for clarity. - Expanded provisions on interfaces. *- Added provisions regarding load path requirements for installation, removal, repair and replacement of equipment.* - Added provisions regarding the design process. - Added provisions regarding design interface control. - Deleted Figs. 3A-1.1, 3A-1.2, and 3A-1.3 regarding design responsibilities and drawing checklists. The following changes were included in the NQA-1c-1988 Addenda: Technical Inquiries - Revised guidelines for preparation of technical inquiries. II - 11 Test Control - Modified item to address computer program tests. S-1 - 2 Definitions - Added definition of computer program. - Revised definition of design output to include computer programs, and added footnotes 2 and 3. 3S-1 - 4, 4.1 Design Verification - Modified to address computer programs. 11S-2 Computer Program Testing - Added Supplementary Requirements for Computer Program Testing. 17S-1 - 4.4.2, 4.4.3 QA Records - Clarified provisions regarding storage facilities and updated NFPA documents to the 1986 Edition. This change incorporates the provisions of NQA-1 Case 1, "Records Storage Facility - Use of NFPA 232. ANSI/ASME NQA-1-1979 with the 1c-1981 Addenda, and Later Editions and Addenda through the 1c-1987 Addenda, Supplement 17S-1, Paragraph 4.4.2." 17A-1 - 3.1 Design Records - Modified item to address computer programs.

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
		The following changes were included in the NQA-1b-1987 Addenda: S-1 - 2 Terms and Definitions - Revised definition [paragraph (a)] for "Commercial Grade Item," and added Footnote 1 regarding nuclear facilities as they relate to commercial grade items. 17A-1 - 1.3 Records - Added provision for using records stored on magnetic or optical media. The following changes were included in the NQA-1a-1986 Addenda: 17S-1 - 4.4.2 Alternate Single Facilities *- Corrected address for NFPA.* 4A-1 - 3.2(a) Document Control - Added guidelines regarding radioactive products and by products.
III-1-A90	NCA-3820(a) Quality System Certificate	This revision restricts the qualification of Material Manufacturers to organizations with a Quality System Certificate (QSC) from ASME or to Certificate Holders who use the material. This change will have a profound effect on many material suppliers who do not have a QSC.
III-1-A90	NCA-3851, NCA-3852(c), NCA-3852(d), NCA-9000 Material Manufacturers and Material Suppliers	This revision clarifies the definitions of organizations which are considered by ASME to be "Material Manufacturers." The revision provides that an organization which machines stock material from one product form to another must be qualified as a Material Manufacturer in order to issue a Certificate for the new product form. A "Material Supplier" who is not qualified as a Material Manufacturer cannot issue Certificates of Compliance or CMTR's with the materials as provided in NCA-3867.4(b).
III-1-A02 (BC01-613)	NE-2211 Exemption from Postweld Heat Treatment for Ferritic Material Test Coupons	This change eliminates the exemption from PWHT for test coupons for P-1, Group 3 ferritic material.

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
III-1-A97 (96-160)	NE-5521(a), NE-5521(a)(1)(a), NE-5521(a)(1)(b), NE-5521(a)(3), NE-5521(a)(4) & Footnotes 1 & 2, NE-5521(a)(6), NE-5530 ASNT SNT-TC-1A	This revision updates the nondestructive examination qualification requirements to the 1992 Edition of SNC-TC-1A. The change requires that personnel performing visual examination be qualified to SNT-TC-1A.
III-1-A95 (94-397)	NE-3338.2(d)(3), XIII-2124(c) Stress Indices for Nozzles	This revision modifies the thickness and diameter dimensional ratios to be consistent with the provisions in Section VIII, Division 2. It restricts the outside nozzle radius on cylindrical shells.
III-1-A95 (94-302)	NE-3112.4 Allowable Stress Intensity and Stress Values	This change identifies the criteria for establishing the allowable stress intensity and allowable stress values for Class MC containments. The allowable stress intensity is now limited to 90% of the yield strength of the material, based on the values given in Table Y-1 of Section II, Part D. This is a new stress limit for containment vessels. The original design philosophy was to allow stresses at 1.1 times the Section VIII allowable stresses, regardless of the yield strength.
III-1-A94 (94-79)	NE-4212, NE-4213 Forming and Bending	This revision adds references for qualifying forming and bending material processes when impact testing is required. The change also revises and clarifies the requirements for confirming minimum wall thickness after forming and bending pipe and tube. The actual thickness may be measured or the forming procedure must show that the required thickness will be maintained.
III-1-A92 (92-174)	NE-4435 Removal of Temporary Attachments	This revision clarifies the fabrication requirements for nonstructural and temporary attachments. The change also reinstates requirements for the examination of the area when temporary attachments are removed. NB-4435(b), NC-4435(b), ND-4435(b), and NE-4435(b) were deleted by mistake in the 1987 Addenda. (TECHNICAL ERRATA to 1987 Addenda.)

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
III-1-A91 (91-226)	NE-7111(b), NE-7727, NE-7734.2(a), NE-7734.3, NE-7735 Laboratory Acceptance of Pressure Relieving Capacity Tests	This revision updates the reference to PCT 25.3 to the 1988 Edition. The change also adds a limit for the coefficient of design.
III-1-A91 (90-340)	NE-7723, NE-7724.2(b), NE-7733, NE-7734.2(b) Pressure Relief Valve Capacity Certification	This revision standardizes the procedure for replacing unacceptable valves, with more restrictive limits, and standardizes and clarifies the types of test failures that are to be used as a basis for ASME refusing certification of a particular valve design.
III-1-A90	Table I-10.2 Stress Tables for Class MC	Austenitic Steels and High Nickel Alloys - Deleted: SA-376 - TP304 (S30400) (NPS 8 & >) (< Sch 140) (ERROR: Corrected 1995 Edition.) (< NPS 8) (Sch 140 & >) *(ERROR: Corrected 1995 Edition.)* TP304H (S30409) (NPS 8 & >) (< Sch 140) (ERROR: Corrected A92 Add.) (< NPS 8) (Sch 140 & >) (ERROR: Corrected A92 Add.) (ERROR: Should have deleted SA-813 - TP309 (S30900) & TP310 (S31000) which were deleted from Section II. Table deleted A91 Add.) (ERROR: Should have deleted SA-814 - TP309 (S30900) & TP310 (S31000) which were deleted from Section II. Table deleted A91 Add.)

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
		- Reduced TS/YS for: SA-376 - TP321 (S32100) (> 3/8 in.) from 75/30 to 70/25 and reduced stress values TP321H (S32109) (> 3/8 in.) from 75/30 to 70/25 and reduced stress values *- Reduced TS/YS for:* (ERROR: Should have reduced TS/YS for: SA-312 - TP321 (S32100) (Sml) (> 3/8 in.) from 75/30 to 70/25) TP321H (S32109) (Sml) (> 3/8 in.) from 75/30 to 70/25) Table deleted A91 Add.) *- Reduced YS from 75 to 70 for:* SA-376 - TP304 (S30400) (NPS 8 & >) (Sch. 140 & >) and reduced stress values (TECHNICAL ERRATA to S72) TP304H (S30409) (NPS 8 & >) (Sch. 140 & >) and reduced stress values (ERROR: This reduction does not apply to TP304H (S30409). Corrected A92 Add.) - Revised stress values for: SA-182 - F321 (S32100), F321H (S32109) SA-213 - TP321 (S32100), TP321H (S32109) SA-240 - 321 (S32100) SA-249 - TP321 (S32100), TP321H (S32109) SA-312 - TP321 (S32100), TP321H (S32109) SA-336 - F321 (S32100), F321H (S32109) SA-376 - TP304 (S30400) (NPS 8 & >) (Sch. 140 & >) TP321 (S32100), TP321H (S32109) SA-403 - 321 (S32100), 321H (S32109) SA-479 - 321 (S32100) SA-813 - TP321 (S32100), TP321H (S32109) SA-814 - TP321 (S32100), TP321H (S32109) - Added notes (15), (16), (17), (18) regarding thickness and pipe sizes.

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
III-1-A90	Table I-10.3 Stress Tables for Class MC	Bolting Materials - Reduced stress values for: SA-193 - B8C (S34700), B8M (S31600)
III-2-A95 (94-307)	CC-3570, CC-3571, CC-3572, CC-3573, CC-3574, CC-3575 Containment External Anchors	This revision adds requirements for anchorage of structural members, supports, and embedments affixed to the external surface of the containment structure.
III-2-A93	CC-3530, CC-3531, CC-3532, CC-3533, CC-3534 Reinforcing Steel Requirements	This revision adds the requirement that mechanical devices for the end anchorages are to be capable of developing at least 125 percent of the specified minimum yield strength of the bar. The change also provides that no reinforcement should be terminated in a tension zone except under certain identified conditions.
III-2-A92 (92-177)	VII-3211 Level I Technician Qualifications	This revision increases the education and experience requirements and clarifies the training and evaluation requirements for Level I Concrete Inspection and Testing Technicians.
III-2-A92 (92-178)	VII-3212 Level II Technician Qualifications	This revision increases the education and experience requirements and clarifies the training and evaluation requirements for Level II Concrete Inspector qualifications.
III-2-A91 (91-210)	CC-3421.8,	This revision revises the design rules for brackets and corbels to be consistent with the provisions in ACI-

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
	CC-3424, CC-3431.3(a), CC-3431.3(c) Brackets and Corbels	318-83. The new rules are much more detailed and modify the formula for determining acceptable shear stress.
III-2-A91 (91-215)	CC-3531, CC-3532, CC-3532(c), CC-3532.1.2(a), CC-3532.1.2(c), CC-3532.1.2(e), CC-3532.1.2(g), CC-3532.1.2(h)(1), CC-3532.1.2(h)(2), CC-3532.1.2(i)(4), CC-3532.1.3, CC-3532.1.5, CC-3532.2.3(b), CC-3533.1(a)(3), CC-3533.1(c), CC-3533.2, CC-3534 Reinforcing Steel	This revision clarifies the requirements regarding design of reinforcing steel. New provisions are added for mechanical devices used for end anchorages.
III-2-A91 (91-217)	CC-3730(c), CC-3740(f), CC-3750(c) Anchorage Design	These new paragraphs provide guidance regarding the design of reinforcing steel for anchorage forces.
III-2-A90	CC-2131.3, CC-2224	This change adds new provisions for mineral admixtures, chemical admixtures and special grouting admixtures as well as adding a new ASTM specification C 1017, "Chemical Admixtures for Use in

Affecting Addenda after 1989 Ed.	Affected chapters	INCREASES IN REQUIREMENTS: differences in ASME Section III 2004 Edition from 1989 Edition, for steel and concrete containment vessels
	Admixtures	Producing Flowing Concrete."
III-2-A90	CC-2131.3.1 & Footnote 10 Laboratory Accreditation for Testing Concrete Constituents	This revision provides that laboratories testing concrete constituents must meet the provisions of ASTM C 1077-87, "Standard Practice for Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation." The purpose of the change is to assure the use of properly qualified laboratories and personnel.
III-2-A90	CC-2232, CC-2233, Table CC-2233.1.2-1, Table CC-2233.2.2-1 Selection of Concrete Mix Proportions	This revision was made to make the provisions concerning concrete mix proportions consistent with the existing ACI-318 Building Code requirements. The change also addresses concerns raised by the American Concrete Institute in a report titled "Special Awareness Concerning Structural Mass Concrete."
III-2-A90	CC-5211, Footnote 4 Laboratory Qualification	This revision provides that tests which are required by CC-5200 are to be performed by an accredited laboratory that complies with ASTM C 1077, "Standard Practice for Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation."
III-2-A90	CC-2231.3 Alkali Content	This revision adds provisions for a program to control alkali content when known reactive materials are present in the aggregate.

NRC RAI 3.8-7

Explain where leak rate test loads are included in the load definitions presented in DCD Section 3.8.1.3. ASME BPVC, Subsection CC-3320, places this load as part of the load P_t and T_t, however, these loads do not appear in the definition of the preoperational loads P_t and T_t described in DCD Section 3.8.1.3.2.

GE Response

The leak rate test (LRT) loads are included in the pre-operational testing loads. Because the magnitude of the LRT pressure is less than that of the structural integrity test (SIT), the LRT loads are not explicitly included in the analysis. The LRT and SIT pressures can be readily compared in DCD Section 6.2.6.1, DCD Table 1.3-3 and DCD Table 3G.1-7.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-8

a) *Explain how the requirements contained in 10 CFR 50.34(f)(3)(v) regarding loads, loading combinations, and design for the ESBWR containment are addressed.*

b) *Explain whether internal flooding of the containment, subsequent to a Loss of Coolant Accident (LOCA), is also applicable to the ESBWR containment design. If so, how is it included in the loading combinations described in DCD Section 3.8.1.3?*

GE Response

a) To satisfy 10 CFR 50.34(f)(3)(v)(A), an evaluation of the Level C pressure capability of major penetrations (Drywell Head, Equipment Hatch, Personnel Airlock and Wetwell Hatch) in the ESBWR concrete containment was performed per ASME Section III, Division 1, Sub article NE-3220. To meet concrete containment requirements of ASME Section III, Division 2, Sub article CC-3720, Factored Load Category, a nonlinear finite element analysis of the RCCV structure including liner plates was performed for over-pressurization. Level C (or Factored Load Category Level) pressure capacity of the concrete containment vessel is at least 1.468 MPa and it is higher than the 1.182 MPa (or 171psi) controlling value of the steel components. The most critical of the piping penetrations is the one for the main steam line. The maximum Level C pressure capability is calculated as 3.377 MPa. The discussion and results are presented in DCD Subsection 6.2.5.4.2 and DCD Table 6.2-46.

   As discussed in DCD Section 6.2.5, ESBWR relies on an inerted containment to control combustible gas. Post accident hydrogen control is not required for an inerted containment according to 10CFR50.44(c)(2). Thus, the requirements in 10 CFR 50.34(f)(3)(v)(B) do not apply.

b) Hydrostatic pressure associated with LOCA flooding during the design phase (i.e. within 72 hours after LOCA) is considered together with other LOCA loads. Internal flooding of the ESBWR containment during fuel recovery stage (i.e. beyond 72 hours after LOCA) is not controlling because the hydrostatic pressure associated with the flooding is less than the containment design pressure.

DCD Tables 3.8-2, 3.8-4 and 3.8-7 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-9

Provide a description of the different subcategories for SRV discharge (e.g., single valve, two valve, automatic depressurization system (ADS), and all valves) and for LOCA (large, intermediate, and small) if applicable, and how they are treated in the load combinations described in DCD Section 3.8.1.3. Also, provide a description and the basis for the method used to combine all of the dynamic loads.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

LOCA (large, intermediate, and small break) and SRV discharges (single valve first actuation, single valve subsequent actuation, and multiple valves) are discussed the in Containment Load Definition (CLD) - NEDE-33261P. The bounding pressure and temperature values are used respectively as accident pressure P_a and LOCA temperature T_a in load combinations for design. The bounding pressure values are used as SRV loads for design. The SRV pressure values for these three limiting conditions (single valve first actuation, single valve subsequent actuation, and multiple valves) are furnished in Table 6 of NEDE-33261P. The multiple valve case bounds ADS. The SRV pressure values for these three limiting conditions cover the different subcategories of SRV discharge (e.g., single valve, two valve, ADS, and all valves). The bounding values of these three limiting conditions are shown in DCD Figure 3B-1 and are considered as SRV loads in DCD Subsections 3.8.1.3 and in the load combination DCD Tables 3.8-2, 3.8-4 and 3.8-7. Depending on the distribution of SRV loads in the suppression pool, they are further classified as axisymmetrical loads, or non-axisymmetrical loads. The SRV pressure loads are applied throughout the entire suppression pool as axisymmetrical SRV (DCD Subsection 3.8.1.4.1.1.2), which represents all of the (or multiple) valve cases. The SRV pressure loads are applied on half of the entire suppression pool as non-axisymmetrical SRV (DCD Subsection 3.8.1.4.1.1.1), which represents the single valve or two-valve case. Because the total load for the axisymmetrical SRV load case is greater than those for the non-axisymmetrical cases, only the former is considered in the RCCV and vent wall design. The design evaluation of the affected structures for SRV loads is performed using equivalent static pressure input equal to a dynamic load factor (DLF) of 2 times the peak dynamic pressure (i.e., the bounding values). The resulting forces or stresses were combined with those due to other loads in the most conservative manner by systematically varying the signs associated with dynamic (including seismic) loads. (See also response to RAI 3.8-48).

The SRV pressure time history and other related information is presented in DCD Appendix 3B. The SRV forcing function as defined in DCD Appendix 3B and the CLD (NEDE-33261P) has a range between 5 to 15 Hz. To perform dynamic analyses to generate response spectra, a finite number of cases using various forcing function frequencies are selected to match with the natural frequencies of the structure to maximize the responses and is described in DCD Appendix 3F as follows:

Axisymmetrical SRV (all) response analysis is covered by n=0 harmonic. Non-axisymmetrical of SRV actuation is covered by n=1 harmonic that corresponds to the effect of the overturning moment.

Frequency range of SRV Loads: $f_1 \leq f \leq f_2$ (f_1 = 5 Hz, f_2 = 12 Hz)

For vertical structural frequencies $(fs)_v$ (n=0):

a. If $(fs)_v > f_2$ then use f_2

b. If $f_1 < (fs)_v < f_2$ then use $(fs)_v$

c. If $f_1 > (fs)_v$ then use f_1

For horizontal structural frequencies $(fs)_h$ (n=1):

a. If $(fs)_h > f_2$ then use f_2

b. If $f_1 < (fs)_h < f_2$ then use $(fs)_h$

c. If $f_1 > (fs)_h$ then use f_1

In an axisymmetrical load case, three vertical frequencies of 5 Hz, 6.06 Hz and 12 Hz are selected. In a non-axisymmetrical load case, 3 horizontal frequencies of 5 Hz, 8.83 Hz and 12 Hz, of the structure satisfying the above selection are adopted as SRV forcing function frequencies.

The bounding response spectra of these cases are documented in DCD Appendix 3F. They are to be used with the response spectra due to seismic and other hydrodynamic loads for the design of safety-related structures, systems, and components inside of containment using the SRSS method of combination.

(1) The applicable detailed report/calculation that will be available for the NRC audit is:

NEDE-33261P, *Containment Load Definition, Revision 1*, May 2006, containing the description of the hydrodynamic loads.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Section 3.7 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-10

Please confirm that application of the 100/40/40 method for combining directional responses discussed in DCD Section 3.8.1.3.6 is consistent with the staff-accepted method, as delineated in draft regulatory guide DG-1127 issued for public comment February 2005. If not, provide the technical basis for the differences.

GE Response

Refer to RAI 3.7-41 for the same question. The 100/40/40 method used is consistent with DG-1127 requirements.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-11

Some subsections in DCD Sections 3.8.1 and 3.8.2 state that the containment design meets specific subarticles and paragraphs of the ASME BPVC, Section III, Division 2. Please confirm that all applicable subarticles and paragraphs contained in the ASME Code are also satisfied. This confirmation should indicate that any exceptions to the ASME Code, such as the allowable tangential shear stress carried by orthogonal reinforcement, have been noted in the DCD.

GE Response

The containment design meets all applicable sub-articles and paragraphs of the ASME BPVC, Section III, Div. 2 except that the code allowable tangential shear stress carried by orthogonal reinforcement (v_{so}) is replaced by a smaller value as shown in DCD Table 3.8-3.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-12

For the various computer programs described in DCD Appendix 3C, applicable to Seismic Category I structures:

a) *Identify which codes have already been reviewed by the NRC on prior plant license applications. Include the name, version, and prior plant license application. This will minimize the review effort needed during the audit.*

b) *Confirm that the following information is available for each computer program, for staff review during the audit: the author, source, and dated version; a description, and the extent and limitation of the program application; a description of how the computer program has been validated; and the user manuals. For those programs that are not widely recognized and in the public domain, more detailed information (including a summary comparison) is expected, in order to demonstrate that the computer program solutions to a series of applicable test problems are similar to solutions obtained by alternative means such as hand calculations, analytical results published in the literature, other similar computer programs, etc.*

GE Response

a) Among all computer programs described in DCD Appendix 3C, NASTRAN, ABAQUS and ANSYS are commercially available programs. GE has no knowledge as to whether or not they have already been reviewed by the NRC during prior plant license applications.

   The ANACAP-U software, which is a concrete and steel constitutive model for ABAQUS, is written and maintained by ANATECH Corp., San Diego, CA. To the best of our knowledge, ANACAP-U has never been reviewed by the NRC as part of a plant license application. However, the ABAQUS/ANACAP-U software combination has been used in many structural investigations and research projects on nuclear structures, including sponsorship by the NRC, DOE, and EPRI. It has also been used in evaluation of other critical infrastructure projects for the U. S. Army Corps of Engineers and State Departments of Transportation. A list of references for this pedigree of the ANACAP-U software is provided as part of the additional information for verification and validation in Part b of the question below.

b) Validation packages for SSDP-2D, DAC3N and TEMCOM2 were provided in response to RAI 3.7-55. The SSDP-2D validation package will be revised in response to RAI 3.8-107, which is a new RAI identified after the NRC staff audit of DCD Section 3.8.

   For ABAQUS and ANACAP-U, the following information will be made available for staff review during the audit: 1) the authors, versions, and general descriptions of ABAQUS and ANACAP-U, 2) the User's Manuals for the versions of both programs used, 3) general theory basis of the programs for determining extent and limitations of applicability, 4) the Verification Manual for ABAQUS, and 5) the Verification and Validation documentation for the ANACAP-U software.

In addition, copies of the following references will be available for review. These references document application of the ABAQUS/ANACAP-U combination software for projects where comparisons between the analyses (usually blind predictions) and experimental data from structural specimen tests are provided or where third party peer reviews of the work were conducted. These are listed in chronological order:

1. NUREG/CR-5341, *Round-Robin Analysis of the Behavior of a 1:6-Scale Reinforced Concrete Containment Model Pressurized to Failure*, Sandia National Laboratories for U. S. Nuclear Regulatory Commission, 1989. This report documents pre-test analysis predictions using the ANACAP-U software against measured results from the scale model tests.
2. Marlow, R. S., *Analytical Simulation of the 241-A-105 Scale-Model Test*, CSA:RSM:ggb:93/2, Westinghouse Hanford Company, Richland WA, 1993. This document describes use, review, and acceptance of the ABAQUS/ANACAP-U software in simulating a test for loading to collapse of a scale model of a reinforced concrete storage tank. This benchmark of the software was done in qualifying the software for use by the U. S. Department of Energy in structural integrity evaluations of the underground nuclear waste storage tanks at the Hanford Reserve, which included thermal stress considerations at elevated temperatures.
3. Bonnard & Gardel, *Bench Mark on Numerical Analysis of Concrete Structures*, HTR Project – Phase 2, Switzerland, 1994. This document provides comparisons from several concrete analysis software packages for blind analysis predictions against specimen tests.
4. ETL 1110-2-365, *Nonlinear, Incremental Structural Analysis of Massive Concrete Structures*, U. S. Army Corps of Engineers, Washington, D. C., August 1994. This document provides specifications and procedures for performing NISA analysis involving thermal-stress analyses and creep, shrinkage, and aging of concrete for the U. S. Army Corps of Engineers. Based on extensive peer review and testing of the ANACAP-U software, this document specifically identifies the ABAQUS/ANACAP-U software in the requirements for conducting these analyses.
5. EPRI TR-108760, *Validation of EPRI Methodology of Analysis of Spent-Fuel Cask Drop and Tipover Events*, Electric Power Research Institute, Palo Alto, CA, August 1997. This report compares measured g-loads from full scale cask drop tests onto R/C slabs against calculated values using the ANACAP-U software.

6. HVD-MDA-D8110-97-4, *Nonlinear Dynamic Structural Analysis of Hoover Dam Including Modeling of Contraction Joints and Concrete Cracking*, U. S. Department of the Interior, Bureau of Reclamation, Denver, CO, September 1997. HVD-MDA-D8110-97-1, "Executive Summary of the Static and Dynamic Stability Studies of Hoover Dam," U. S. Department of the Interior, Bureau of Reclamation, Denver, CO, May 1998. These reports document the use, review, and acceptance of the ANACAP-U software by the Bureau of Reclamation and an external technical review board in evaluating the seismic stability of the Hoover Dam.

7. NUREG/CR-5671, *Pretest Prediction Analysis and Posttest Correlation of the Sizewell-B 1:10 Scale Prestressed Concrete Model Test*, ANATECH Research Corp for U. S. Nuclear Regulatory Commission, 1998. This report compares analyses using the ANACAP-U software with test data for over-pressurization tests of a prestressed concrete containment vessel (PCCV) model.

8. NUREG/CR-6639, *Seismic Analysis of a Prestressed Concrete Containment Vessel Model*, Sandia National Laboratories for U. S. Nuclear Regulatory Commission, 1999. This report documents the comparisons between ANACAP-U analyses and test results for a series of increasing seismic demands until failure of a prestressed concrete containment vessel (PCCV) model.

9. NUREG/CR-6707, *Seismic Analysis of a Reinforced Concrete Containment Vessel Model*, Sandia National Laboratories for U. S. Nuclear Regulatory Commission, 2000. This report documents the comparisons between ANACAP-U analyses and test results for a series of increasing seismic demands until failure of a reinforced concrete containment vessel (RCCV) model.

10. NUREG/CR-6809, *Posttest Analysis of the NUPEC/NRC 1:4 Scale Prestressed Concrete Containment Vessel Model*, Sandia National Laboratories for U. S. Nuclear Regulatory Commission, 2003. This document provides correlations between ANACAP-U analyses and test data for overpressure failure of a prestressed concrete containment vessel (PCCV) model.

11. *Resistance of Nuclear Power Plant Structures Housing Nuclear Fuel to Aircraft Crash Impact*, EPRI Report (not for public disclosure), Palo Alto, CA, Feb 2003. *Aircraft Crash Impacts at Nuclear Power Plants – Validation of Analysis Methodology*, ANATECH Report ANA-03-0637 to EPRI, 2003. *Aircraft Impacts at Nuclear Power Plants – Analyses for Impacts into BWR Spent Fuel Support Structures*, ANATECH Report ANA-05-0683 to EPRI, 2005. These reports document results of peer-reviewed work using the ANACAP-U software for studies on structural damage to nuclear power plant facilities from aircraft crash impacts. These reports are not available for review without consent from EPRI.

However, the next 2 references in the public domain document some of the validation work performed for the ANACAP-U software used in the studies.

12. James, R. J., Zhang, L., Rashid, Y. R., *Impact of High Velocity Objects into Concrete Structures – Methodology and Application*, Proceedings of 2003 ASME International Mechanical Engineering Congress, Washington, D. C., November 16-21, 2003. This paper provides benchmark comparisons for ANACAP-U analyses with test data for rigid missile impacts on reinforced concrete slabs.

13. James, R. J. and Rashid, Y. R., *Severe Impact Dynamics of Reinforced Concrete Structures*. Proceedings of the 6th European Conference on Structural Dynamics, Paris, France, September 4-7, 2005. This paper provides benchmark comparisons of test data to analytical simulations using the ANACAP-U software for crushable missile impacts on reinforced concrete slabs causing extensive structural damage.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-15

Describe how all of the pressure loads acting on the containment and internal structures are calculated and applied to the containment. (DCD Section 3.8.1.4.1.1, Appendix 3G.1.5.2.1.7, and Appendix 3B) This should include how axisymmetric and nonaxisymmetric loads are applied and how variations in pressure definition parameters (phasing of maximum pressure on different pool boundary locations, dynamic load factor (DLF), variation in loading function frequencies, etc.) are considered. The description should include pressures due to normal operating, accident pressures, and SRV actuations. Explain if negative pressure loads (i.e., net positive external pressure) acting on the containment can occur and will upward pressure loading on the diaphragm floor develop under any conditions. Appendix 3B – Hydrodynamic Load Definitions needs to be expanded to include this information. Some information is presented in App. 3B, however it appears that much of the description is applicable to response spectra generation using a different model than the NASTRAN finite element model.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

Figures 3.8-15(1), 3.8-15(2) and 3.8-15(3) show the transient pressure envelopes at DBA, the areas subject to differential pressure between the Reactor Building and Containment, and areas subject to differential pressure between Drywell and Wetwell. Table 3.8-15(1) shows the load combination for design pressure loads. This table shows four load phases considered critical cases for design. Two of these two cases (e.g., 6 min. and 72 hours after LOCA) are presented in the DCD. The DLF is not considered for the pressure loads.

The information for Hydrodynamic loads presented in DCD Figures 3G.1-21 through 23, and DLF=2 is used for SRV, CO and CHUG to cover the variation in loading function frequencies. The use of DLF of 2 is believed to be conservative which will be confirmed by dynamic analysis in the detailed design phase. Only the axisymmetric loads (both positive and negative cases) are considered since they are more severe than nonaxisymmetric loads. The method of load application to the FEM model is shown in Figure 3.8-15(4).

A differential pressure of –20.7 kPad (–3.0 psid) is generated in the RCCV as a result of steam quenching after a break caused by drywell spray actuation. The diaphragm floor (DF) and vent structure are subject to this differential pressure acting from the Wetwell to the Drywell. It is combined with CHUG in the load combination. As presented in the Containment Load Definition (NEDE-33261P), the DF is only subjected to downward pressure differential loading during the pool swell phase.

As for internal structures, the pressure loads acting on them are the same as for the RCCV. In addition, AP loads including pressure on the inner surface of the RSW, nozzle jet, impingement jet and pipe whip restraint loads are applied as nonaxisymmetric loads. The application of AP load is described in DE-OG-0077, *AP Load Evaluation for RSW Model Input Data, Revision 0,* July 2006, which contains how the dynamic response of RSW to AP loads are calculated.

The diaphragm floor (DF) slab is designed to the downward pressure of 35 psid. The DF slab is also subjected to an upward pressure of 3 psid as shown in Figure 3.8-15(3). It is not controlling.

Regarding the vent wall structure, the pressure loads acting on its outer surface are the same as Wetwell portion of the RCCV, and those acting on the inner surface of it are the same as the Drywell portion of the RCCV.

(1) The applicable detailed reports/calculations that will be available for the NRC audit are:

   a. 26A6651, *Reactor Building Structural Design Report, Revision 1,* October 2005, containing the structural analysis and design of Reactor Building structure including RCCV

   b. NEDE-33261P, *Containment Load Definition, Revision 1,* May 2006, containing description of hydrodynamic loads.

   c. DE-OG-0077, *AP Load Evaluation for RSW Model Input Data, Revision 0,* July 2006, which contains how the dynamic response of RSW to AP loads are calculated.

(2) This information exists as part of GE's internal tracking system.

No DCD changes will be made in response to this RAI.

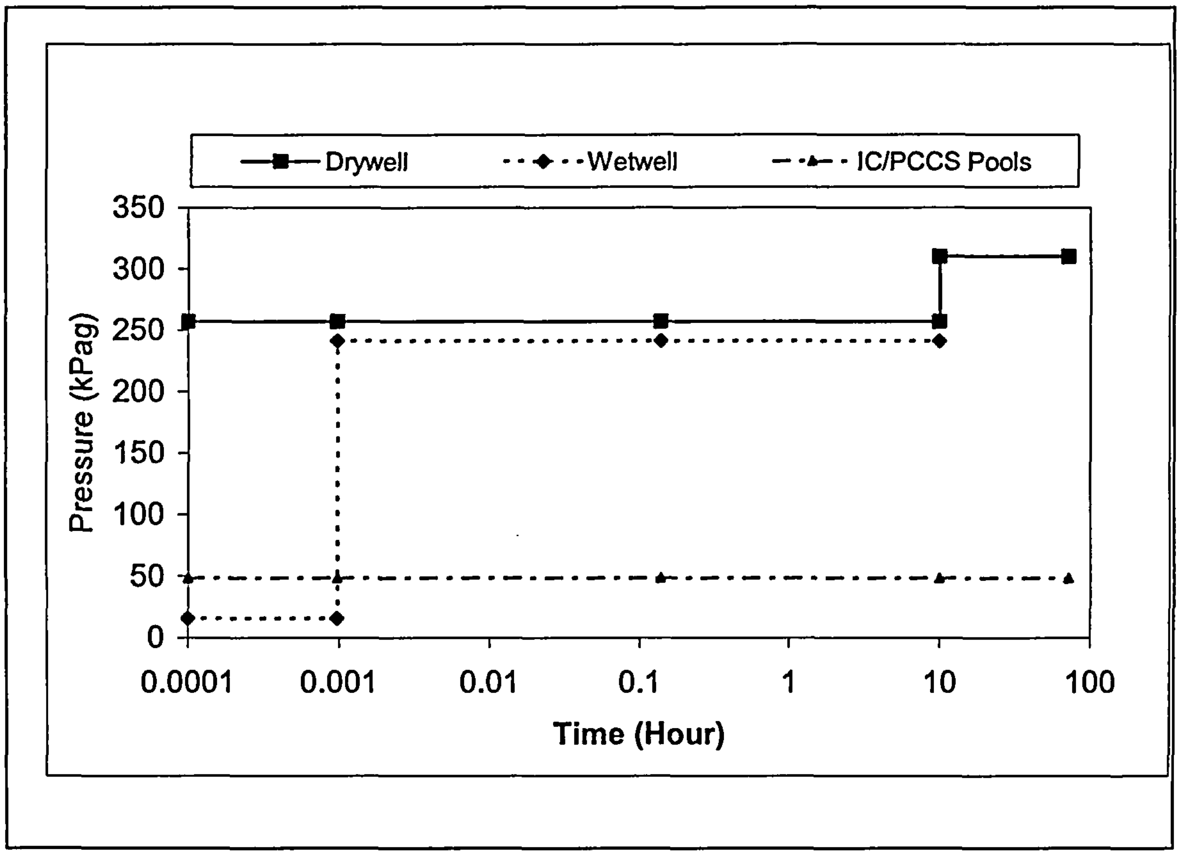
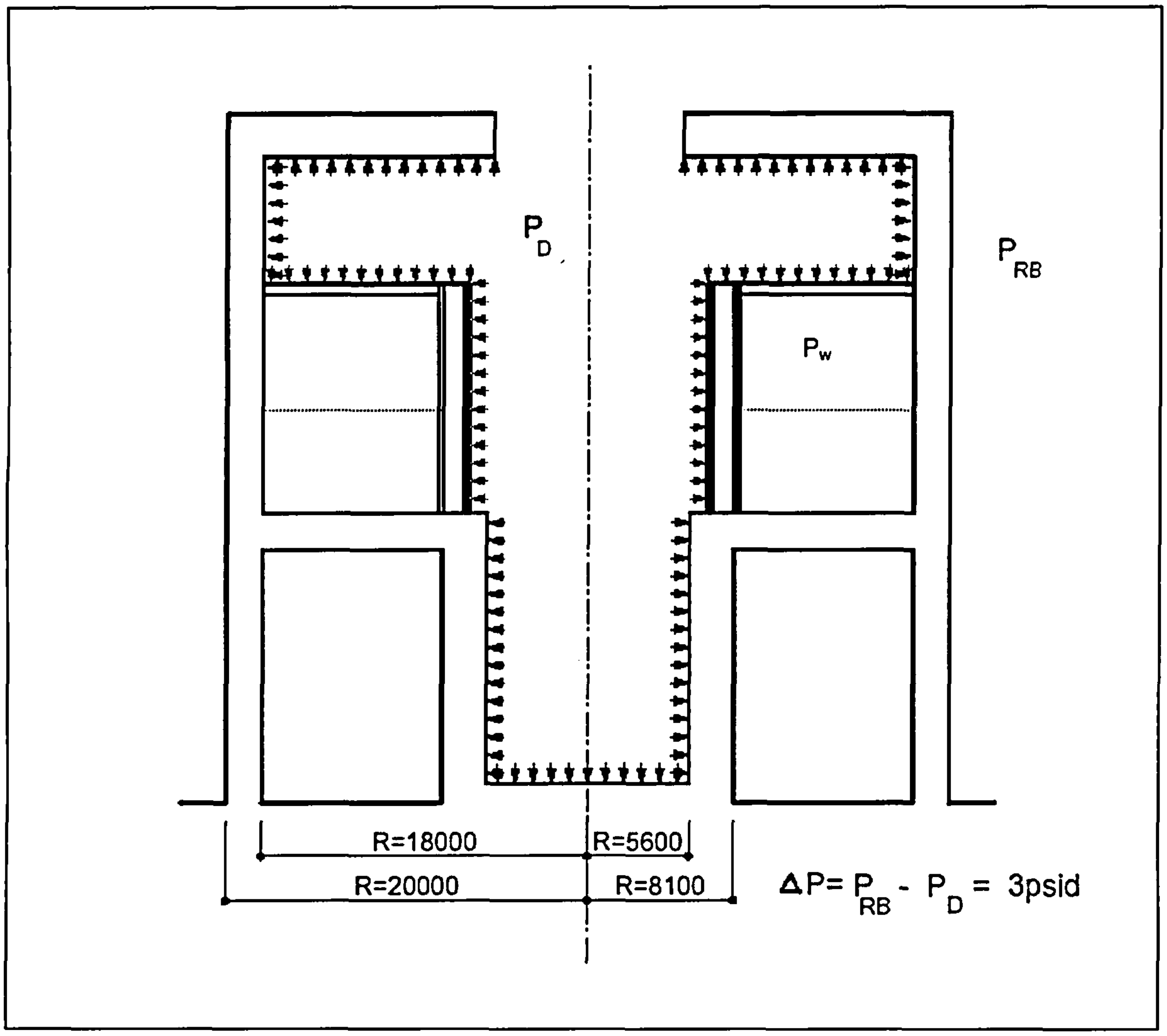
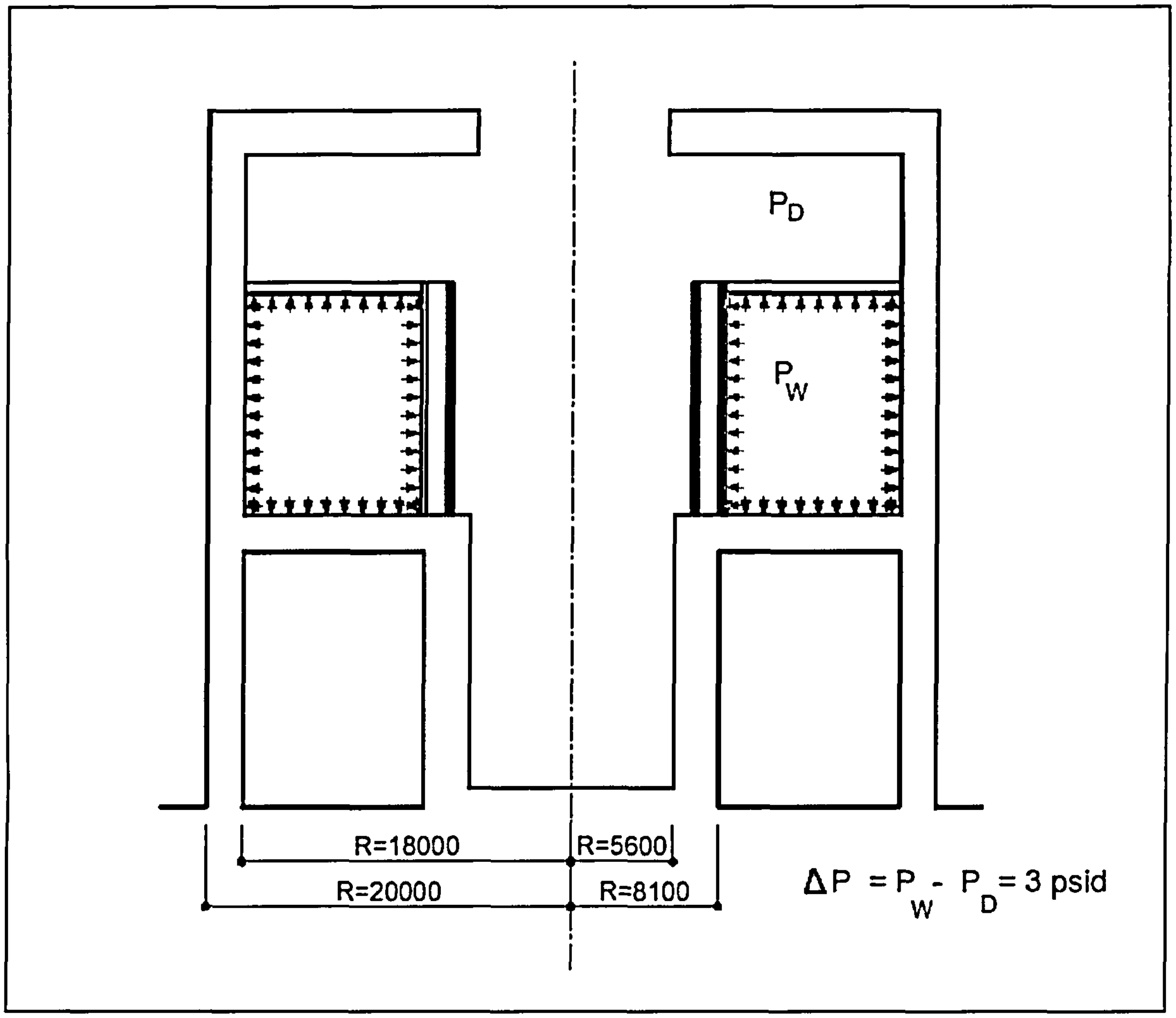


Figure 3.8-15(1) Envelopes of Transient Pressure Curves at DBA



Note: (i) $\Delta P = P_{RB} - P_D$ or $P_{RB} - P_W$
(ii) Higher Pressure in RB than in Drywell or Wetwell

Figure 3.8-15(2) - Differential Pressure (ΔP) Between Reactor Building (RB) and Containment



Note: Higher Pressure in Wetwell

Figure 3.8-15(3) Differential Pressure Between Drywell and Wetwell

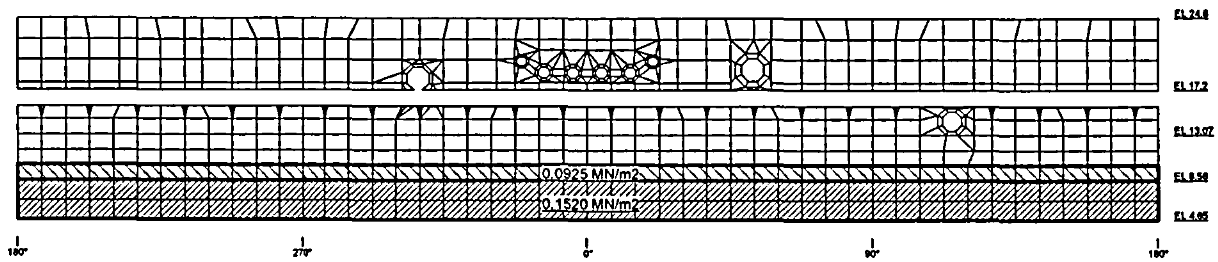


Figure 3.8-15(4) Application of Hydrodynamic Load on the RCCV Liner (SRV Positive)

Table 3.8-15(1) Load Combinations for Design Pressure Loads

			Drywell*1	Wetwell*1	IC/PCCS*1	Main Steam Tunnel*1	Note
		Label	PDW	PSC	PIC	PMS	
TEST	Max.	PTL1	0.3568	0.3568			
	Diff.	PTL2	0.3100	0.0325			Max. Differential Pressure 277.5kPa
Normal Operation		POL	0.0052	0.0052	0.0345		
LOCA	After 5 seconds	PL1	0.0000*2	0.0000*2	0.0483		Period-I
	After 6 minutes	PL2	0.2570	0.2410	0.0483		Period-II
	After 10 hours	PL3	0.3100	0.3100	0.0483		Period-IV
	After 72 hours	PL4	0.3100	0.3100	0.0483		Period-IV
HELB		PLMS				0.0760	HELB in MS Tunnel

Note: *1: Unit pressure load, 1.0 MPa, is applied to each space in stress analyses.
*2: The pressure loads at 5 seconds are considered in the Pool Swell Pressure Load.

NRC RAI 3.8-16

Provide a description of how the dynamic fluid effects (water mass, fluid-structure interaction, sloshing) associated with the suppression pool, other pools, and water above the drywell head are considered in the model development, analysis, and design of the containment and RB, subjected to the various dynamic loading events. (DCD Section 3.8.1.4.1 and Appendix 3G)

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

Two kinds of dynamic fluid effects are considered in the design of the containment and buildings. One is hydrodynamic loads of the suppression pool water, and the other is sloshing loads due to earthquakes.

The approach described in ASCE 4-98 together with the discussions given in BNL Report 52361 is followed. See response to RAI 3.7-53.

(1) The applicable detailed reports/calculations that will be available for the NRC audit are DC-OG-0053, *Structural Design Report for Containment Internal Structures, Revision 2*, October 2005, containing evaluation method and results for structural integrity of containment internal structures, and 26A6651, *RB Structural Design Report, Revision 1*, November 2005, containing the structural design details of the Reactor Building.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-21

Explain why DCD Section 3G.1.5.4.1.1 indicates that the liner maximum strain is 0.0040 while Table 3G.1-35 tabulates a higher value of 0.005, at the cylinder portion of containment under the abnormal loading combination. If the 0.005 strain (in compression) is correct, then it exceeds the ASME Code allowable value of 0.003.

GE Response

The subject strain value is 0.0005, and it is less than the ASCE Code allowable value of 0.003. DCD Table 3G.1-35 contains a typographical error.

DCD Table 3G.1-35 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-22

With regard to DCD Section 3.8.1.4.1.4:

a) *Explain why the amount of corrosion used for assessing the 60-year life of the suppression pool liner is based on the annual temperature profile of the pool water "for a typical plant in southern states."*

b) *Provide the basis for the 0.12 mm total corrosion allowance used for the Type 304L stainless steel liner/clad material. Identify what is the expected corrosion and how was it determined.*

GE Response

a) The annual temperature profile of the pool water in southern states was used for corrosion assessment since higher temperatures usually are associated with higher corrosion rates. Since the corrosion allowance is the same for temperatures up to 316°C for Type 304L stainless steel per DCD Section 3.8.1.4.1.4, the corrosion allowance is not affected by the average temperature profile used.

b) The 0.12 mm corrosion allowance is based on GE's internal design guidance for corrosion allowances for reactor system components (i.e. stainless steel in reactor water at 550° F). This allowance was scaled up to 60 years and conservatively applied to the pool liner. This is conservative because the expected corrosion rate for ambient temperature exposure will be substantially lower than at reactor operating conditions with flow. This design allowance has been used for the design of stainless steel BWR components for the last 30 years.

   PDMA PIRT Report – Appendix A dated June 3, 2005 entitled *Material Degradation Modes and their Prediction*, Page A-16, gives an actual general corrosion rate of 0.01 mils/yr of service life in a BWR reactor coolant operating environment in the 500°F - 600°F temperature range. Applying this rate to the suppression pool environment would equate to an expected corrosion of 0.6 mils (0.01524 mm) for a plant life of 60 years. The 0.12 mm corrosion allowance provided is over 7.5 times this value and is very conservative.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-29

DCD Table 3G.1-36 identifies that the Service Level A, B primary + secondary stress condition in the drywell head exceeds the basic code allowable stress by 75% (PL+Pb+Q is 794 MPa calculated vs. 456 MPa allowable). Describe in detail and pictorially the geometry/location of all overstress conditions. Explain why Q is 11 times greater than PL+Pb. Identify the loading condition(s) that created this overstress condition (pressure loads, thermal loads, or a combination). Provide the technical basis for relying on the NE-3228.3 analysis to show acceptability, rather than implementing a design modification to alleviate the high secondary stress. Provide the details of the NE-3228.3 analysis. Include this information in DCD Section 3.8.2 and/or Appendix 3G.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

The high stress value is due to thermal loads from the LOCA condition. Since the DW head is fixed at the cylindrical part to the concrete slab, high discontinuity stresses are present at the joint. This is secondary stress and cannot be alleviated by design modification. The portion where the high stress occurs is shown in Figure 3.8-29(1). P_L+P_b is the primary membrane stress so it does not include thermal stress, and the stress value is at the center of the plate thickness, while P_L+P_b+Q is the primary plus secondary stress including thermal stress, and the stress value is at the surface of the plate. Therefore, P_L+P_b+Q is much higher than P_L+P_b. Under this type of secondary stress, the ASME permits a simplified elasto-plastic analysis in NE-3228.3. The details of the NE-3228.3 analysis will be included in DCD Section 3G.1.5.4.1.4 in the next DCD revision as noted in the attached markup.

(1) The applicable detailed report/calculation that will be available for the NRC audit is DC-OG-0052, *Structural Design Report for Containment Metal Components, Revision 1*, September 2005, containing the evaluation method and results for structural integrity of the containment liner and drywell head.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Section 3G.1.5.4.1.4 will be revised in the next update as noted in the attached markup.

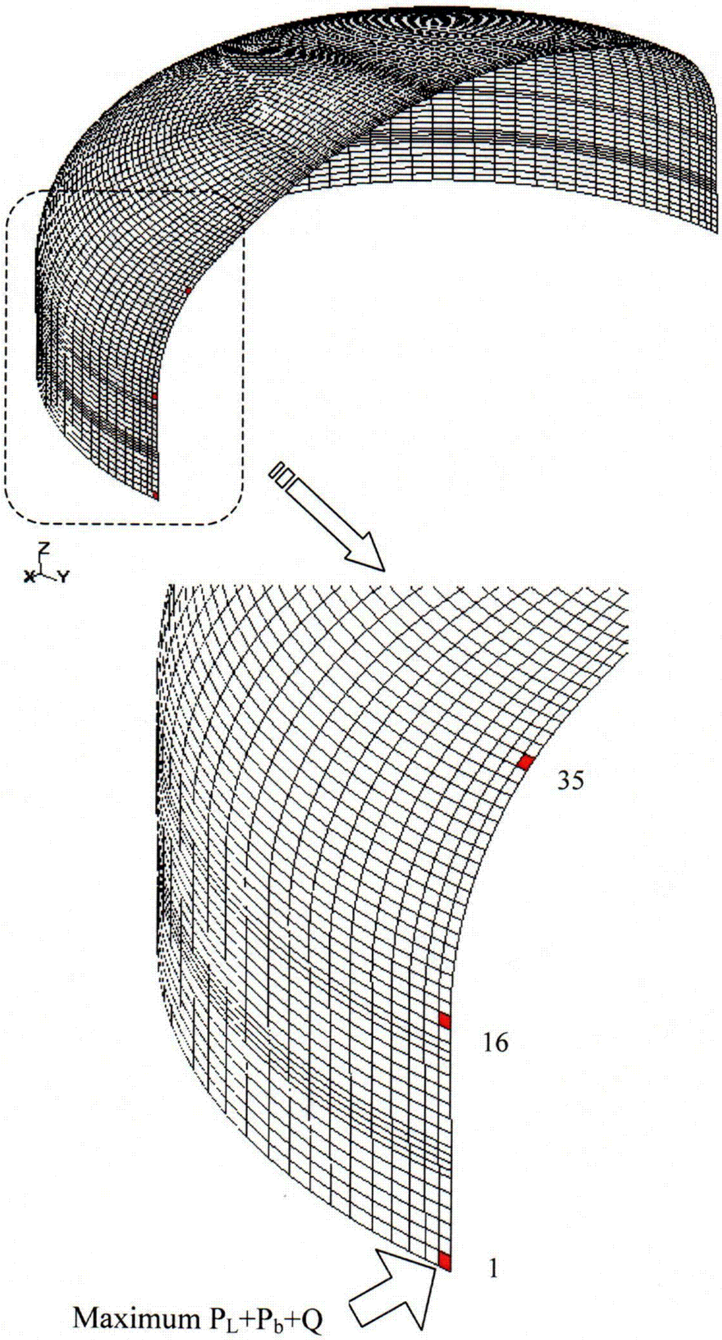


Figure 3.8-29(1) High Secondary Stress Portion due to T_a = 171°C

NRC RAI 3.8-30

DCD Figure 3G.1-51 indicates there is stainless steel (SS) cladding on the exterior surface of the drywell head. Describe the purpose for the SS cladding. If there is water in the space above the drywell head during normal operation, what is the height of water in this space? What is the cladding thickness? How was the SS cladding modeled in the Service Level A and B pressure and thermal analyses of the drywell head? Was the mismatch in thermal expansion coefficients between carbon steel and SS considered in the thermal analyses? Include this information in DCD Section3.8.2 and/or Appendix 3G.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

There is water in the reactor well above the drywell head during normal operation. The height of water is 6.7 m. The purpose of the SS cladding is to provide corrosion protection of the carbon steel base plate. Cladding is not considered in the analysis model, because the strength of cladding is not considered for primary stress based on ASME NE-3122.1. Since the stress of cladding is classified as peak stress in ASME Table NE-3217-1, only fatigue analysis is required for the cladding. Fatigue analysis will be performed to address RAI 3.8-32. In the provision of NE-3122, there is no requirement for cladding thickness; however, NB-3122.3 stipulates that the presence of the cladding may be neglected if the cladding is 10% or less of the total thickness of the component. Therefore the cladding thickness will be determined in the detailed design in accordance with NB-3122.3 requirements, so it results in negligible stress in the base metal.

(1) The applicable detailed report/calculation that will be available for the NRC audit is 26A6558, *General Civil Design Criteria, Revision 1*, November 2005, which contains the depth of water in the reactor cavity pool.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Section 3.8.2.1.4 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-31

Figure 3G.1-51, Detail C, shows six (6) drywell head support brackets. Please explain their function. How were the brackets modeled in the Service Level A and B pressure and thermal analyses of the drywell head? Were local discontinuity stresses and peak stresses calculated and considered in the Code evaluation? If yes, describe the results. If not, explain why not. Include this information in DCD Section 3.8.2 and/or Appendix 3G.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

These support brackets are attached to the inner surface of the DW head circumferentially to support the head on the operating floor during refueling. These support brackets have no stiffening effect and do not resist loads when the head is in the installed configuration (stiffening effect is local and active only during refueling when the head is in its stored position). They are not considered in the design analysis model of the drywell head.

(1), (2) No detailed report exists since the effects of these supports are not evaluated.

DCD Section 3.8.2.1.4 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-39

DCD Section 3G.1.5.2.2.2 states that W, W', Ro, Ra, Y, SRV, and LOCA are small and are neglected for the drywell head. Provide a technical basis for this conclusion, for each of these loads. Include this information in DCD Section 3.8.2 and/or Appendix 3G.

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

These loads do not act on the drywell head directly. The indirect effect under these loads is evaluated in terms of deformations of the supporting RCCV top slab. The strains of the top slab at the drywell head opening calculated from the global NASTRAN analysis for these loads are very small, and as a result, these loads are negligible to the drywell head design.

(1) The applicable detailed report/calculation that will be available for the NRC audit is DC-OG-0052, *Structural Design Report for Containment Metal Components, Revision 1*, September 2005, which contains the evaluation method and results for structural integrity of the containment liner and drywell head.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Section 3G.1.5.2.2.2 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-42

DCD Section 3.8.3.1.6 discusses platforms that are classified as Seismic Category I (C-I) and Seismic Category II (C-II). However, no description is provided regarding how they are analyzed or designed. Some information is presented in DCD Section 3.7, which states that Seismic Category II structures, systems, and components (SSCs) are "designed and/or so physically arranged that the SSE [safe shutdown earthquake] would not cause unacceptable structural interaction or failure." It also states that the methods of seismic analysis and design acceptance criteria for C-II SSCs are the same as C-I; however, the procurement, fabrication, and construction requirements for C-II SSCs are in accordance with industry practices. Based on the above:

a) Explain what is meant by the statement "designed and/or so physically arranged that the SSE would not cause unacceptable structural interaction or failure." Provide sufficient information for the staff to confirm that the approach satisfies the three criteria presented in SRP 3.7.2 II,8 for all C-I SSCs.

b) Describe any other SSCs that are Seismic Category II inside containment.

Include this information in DCD Section 3.8.3.1.6.

GE Response

a) DCD Section 3.7 will be revised to delete the words "physically arranged". The methods of seismic analysis and design acceptance criteria for Seismic Category II (C-II) SSCs are the same as C-I SSCs. C-II SSCs meet the SRP 3.7.2.II.8 criteria and are designed to prevent their collapse under an SSE.

b) SSCs inside containment are classified as Seismic Category II if they do not perform or support safety-related functions.

DCD Sections 3.7 and 3.8.3.1.6 will be revised in the next update as noted in the attached markups.

NRC RAI 3.8-43

DCD Section 3.8.3.2 indicates that the design of all containment internal structures conform to ANSI/AISC N690-194s2 (2004). This standard has not been formally reviewed and accepted by the staff. However, the staff has previously accepted ANIS/AISC N690-84 subject to supplemental requirements described in Appendix G of NUREG-1503 (NRC safety evaluation report (SER) on ABWR). Therefore, identify all differences between ANSI/AISCN690-1994s2 (2004) and ANIS/AISC N690-84 (with NRC-accepted supplemental requirements) that affect the ESBWR design. Provide the technical basis which ensures that a comparable level of safety is achieved for each such difference between the two standards.

GE Response

In the attached table, the differences between ANSI/AISC N690-1994s2 (2004) and ANSI/AISC N690-84 (with NRC-accepted supplemental requirements) that affect the ESBWR design are compared and summarized. As shown in the table, the following items are the most important ones that affect the design of ESBWR containment internal steel structures.

1. Secondary stress: One of the major supplemental requirements described in Appendix G of NUREG-1503 is that secondary stress should apply to stresses developed by temperature loading only. This concept is clarified in Q1.0.2 and is also reflected in Load Combination 9a of ANSI/AISC N690-1994s2 (2004) considered in the design of containment internal steel structures of the ESBWR. Thermal stress in the containment internal steel structures of the ESBWR is considered as secondary stress and conforms to the supplemental requirement (1) in Appendix G of NUREG-1503.
2. Reducing factor 0.9: In Q1.3.6 of ANSI/AISC N690-1994s2 (2004), the reducing factor 0.9 is used the same as the supplemental requirement in Appendix G of NUREG-1503. Containment internal steel structures of ESBWR follow ANSI/AISC N690-1994s2 (2004) and thus conform to NRC's position given in Appendix G of NUREG-1503.
3. As shown in the attached table, the stress limit coefficients (SLC) in Table Q1.5.7.1 of ANSI/AISC N690-1994s2 (2004) are not exactly the same as those of (3) in Appendix G of NUREG-1503. However, with the limitation on secondary stress to thermal stress, an added load combination 9a and an additional note k being introduced into ANSI/AISC N690-1994s2 (2004), the intent of SLCs in NRC's position (3) of Appendix G to NUREG-1503 is addressed. Containment internal steel structures of ESBWR follow ANSI/AISC N690-1994s2 (2004) and thus conform to the intent of NRC's position (3) given in Appendix G of NUREG-1503.

4. According to Appendix G of NUREG-1503, the ductility factors in Table Q1.5.8.1 should not be used in load combinations 9, 10, and 11. For impact and impulsive loads, the provisions of item II.2 of Appendix A to SRP Section 3.5.3 should be substituted for the ductility factors in Table Q1.5.8.1. For the design of ESBWR containment internal steel structures, the ductility factors in Table Q1.5.8.1 are used with the condition in Section Q1.5.7.2 only for load combinations involving thermal loads. For impact and impulsive loads, the provisions of item II.2 of Appendix A to SRP Section 3.5.3 are to be used.

See RAI 3.8-66 for additional DCD changes. DCD Table 3.8-6 will be revised in the next update to include RG 1.54.

DCD Table 3.8-6 will be revised in the next update as noted in the attached markup.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-7)
(1) Q1.0.2: Secondary stress should apply to stresses developed by temperature loading only.	Q1.0.2: A secondary stress is any normal stress or shear stress developed by the constraint of adjacent material or by self-constraint of the structure.	Q1.0.2: A secondary stress is any normal stress or shear stress developed by the constraint of adjacent material or by self-constraint of the structure.	Q1.0.2: Secondary stress is a stress developed by the self-constraint of a structure rather than from external loads. The basic characteristic of a secondary stress is that it is self-limiting.	Thermal stress is considered as secondary stress.
(2) In Q1.3.6, add: a) When any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load should be taken as zero. b) Where the structural effects of differential settlement are present, they should be included with the dead load D. c) For structures or structural components subjected to hydrodynamic loads resulting from a loss-of-coolant accident (LOCA) and/or safety/relief valve (SRV) actuation, the consideration of such loads should be as indicated in the appendix to Standard Review Plan (SRP) Section 3.8.1. Any fluid structure interaction associated with these hydrodynamic loads and those from the postulated earthquake(s) should be taken into account.	No equivalent requirement is given in Q1.3.6.	No equivalent requirement is given in Q1.3.6.	In Q1.3.6, add: a) When any load reduces the effects of other loads and if it can be demonstrated that the load is always present or occurs simultaneously with other loads, the corresponding coefficient for that load shall be taken as 0.9. Otherwise, the coefficient for that load should be taken as zero. b) No equivalent requirement given in Q1.3.6. c) See Q1.3.7.	a) Same as N690-1994s2. b) Differential settlement not applicable for internal containment structures. c) Considered in DCD Table 3.8-7.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-7)
(3) The stress limit coefficients (SLC) for compression in Table Q1.5.7.1 should be as follows: 1.6 instead of 1.7 in load combination 11; 1.4 instead of 1.6 in load combinations 7, 8 and 9; 1.3 instead of 1.5 (stated in footnote (c)) for load combinations 2, 5 and 6.	The stress limit coefficients (SLC) for compression in Table Q1.5.7.1 are as follows: • 1.7 in load combination 11. • 1.6 in load combinations 7, 8 and 9 • 1.5 (stated in footnote (c)) for load combinations 2, 5 and 6.	Same as AISC N690-1984	Same as AISC N690 -1984 except the following: (i) Load Combination 9a. D+L+Ta+Pa with stress limit coefficient 1.6 is added in the Abnormal Category. (ii) Note j, "This load combination is to be used when the global (non-transient) sustained effects of Ta are considered." is added to Load Combination 9(a). Note k, "The stress limit coefficient where axial compression exceeds 20% of normal allowable, shall be 1.5 for load combination 7,8,9,9a and 10 and 1.6 for load combination 11.	Same as N690-1994s2.
(4) The following note should be added: For constrained (rotation and/or displacement) members supporting safety-related structures, systems, and components (SSCs), the stresses under load combinations 9, 10 and 11 should be limited to those allowed in Table Q1.5.7.1 as modified by Provision 3 above. The ductility factors of Table Q1.5.8.1 (or Provision 5 below) should not be used in these cases.	No equivalent requirement is given in Table Q1.5.8.1.	No equivalent requirement is given in Table Q1.5.8.1.	Same as above	Same as N690-1994s2. Ductility factors in Table Q1.5.8.1 are used with the condition in Section Q1.5.7.2 only for load combinations involving thermal loads.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-7)
(5) For ductility factors μ in Sections Q1.5.7.2 and Q1.5.8, the provisions of Item II.2 of Appendix A to SRP Section 3.5.3 should be substituted for the ductility factors in Table Q1.5.8.1.	Ductility factors in Table Q1.5.8.1 are different from those in Appendix A to SRP Section 3.5.3. [	Ductility factor for elements in uniform compression due to bending in Table Q1.5.8.1 of N690 (1984 edition) is deleted in Table Q1.5.8.1 of N690 (1994 edition).	Q1.5.8 DESIGN BASED ON DUCTILITY AND LOCAL EFFECTS - In subparagraph a, delete Ta from the list of load effects. In the title of Table Q1.5.8.1, replace "EXTREME AND ABNORMAL LOADS' with "IMPACTIVE AND IMPULSIVE LOADS".	Same as N690-1994s2. Ductility factors in Appendix A to SRP Section 3.5.3 are substituted for the ductility factors in Table Q1.5.8.1 for impact and impulsive loads.
(6) In load combination 9 of Section Q2.1, the load factor applied to load Pa should be 1.5/1.1»1.37, instead of 1.25.	In load combination 9 of Section factor applied to load Pa is 1.25.	In load combination 9 of Section W2.1, the load factor applied to load Pa is 1.25.	No information is available	Plastic design is not used. Q2.1 is not applicable to ESBWR.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-7)
(7) Sections Q1.24 and Q1.25.10 should be supplemented with the following requirements regarding the painting of structural steel: Shop painting is to be in accordance with Section M3 of load and resistance factor design (LRFD) specifications (American Institute of Steel Construction, "Load and Resistance Factor Design for Structural Steel Buildings and Its Commentary," Chicago, IL, 1986). All exposed areas after installation are to be field painted (or coated) in accordance with the applicable portion of Section M3 of the LRFD specification. The quality assurance requirements for the painting (or coating) of structural steel are to be in accordance with ANSI N101.4 (American Institute for Chemical Engineers, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," New York, 1972) as endorsed by Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water Cooled Nuclear Power Plants," Revision 0.	Q1.24 SHOP PAINTING Shop painting shall be as specified by the Engineer. Q1.25.10 FIELD PAINTING Field painting shall be as specified by the Engineer.	Q1.24 SHOP PAINTING Shop painting shall be as specified by the Engineer. Q1.25.10 FIELD PAINTING Field painting shall be as specified by the Engineer	Q1.24 SHOP PAINTING Q1.24.1 GENERAL REQUIREMENTS Shop painting and surface preparation shall be in accordance with the provisions of the Code of Standard Practice of the American Institute of Steel Construction, Inc. Unless otherwise specified, steelwork that will be concealed by interior building finish or will be in contact with concrete need not be painted. Unless specifically excluded, all other steelwork shall be given one coat of shop paint. The quality assurance requirements for painting (or coating0 of structural steel shall be in accordance with ASTM D3843 as endorsed by Regulatory Guide 1.54. Q1.24.2 INACCESSIBLE SURFACES Except for contact surfaces, surfaces inaccessible after shop assembly shall be cleaned and painted prior to assembly, if required by the design documents. Q1.24.3 CONTACT SURFACES Paint is permitted unconditionally in bearing-type connections. For slip-critical connections, the faying surface requirements shall be in accordance with the RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts, paragraph 3.2.2.	Same as N690-1994s2 The quality assurance requirements for painting meet standards endorsed by Regulatory Guide 1.54.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-7)
			Q1.24.4 FINISHED SURFACE Machine-finished surfaces shall be protected against corrosion by a rust-inhibiting coating that can be removed prior to erection, or which has characteristics that make removal prior to erection unnecessary. Q1.24.5 SURFACES ADJACENT TO FIELD WELDS Unless otherwise specified in the design documents, surfaces within 2 in. of any field weld location shall be free of materials that would prevent proper welding or produce toxic fumes during welding. Q1.25.10 FIELD PAINTING Replace current text with the following: Responsibility for touch-up painting, cleaning and field-painting shall be allocated in accordance with accepted local practices, and this allocation shall be set forth explicitly in the design documents.	

NRC RAI 3.8-45

DCD Table 3.8-6 lists codes, standards, specifications, and regulations used in the design and construction of seismic Category I Internal Structures of the containment. Please explain why ASME-2004 is identified within this table.

GE Response

ASME-2004 will be deleted from DCD Table 3.8-6.

DCD Table 3.8-6 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-50

a) *DCD Section 3.8.3.4.2 states that the RPV feet can slide radially, and therefore there are no thermal expansion loads from the RPV support acting on the RPV support bracket. Since frictional resistance could potentially induce thermal expansion loads during radial thermal growth of the RPV, describe the RPV feet/RPV support bracket design features that minimize frictional resistance to sliding, including the coefficient of friction between the surfaces in contact.*

b) *Although a description is provided about the design of the RPV support bracket allowing unrestrained radial growth, it does not discuss how the design resists horizontal loads. Provide a description of how the RPV support bracket resists horizontal forces for all applicable loads. Include this information in DCD Section 3.8.3 and/or Appendix 3G.*

In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

a) In order to provide a low friction coefficient (~0.15) that minimizes the resistance to sliding in the RPV foot/RPV support bracket interface, bearing plates of Lubron alloy GA50 are placed between the sliding components. Therefore, there are no significant thermal expansion loads from the RPV supports acting on the RPV support brackets.

b) Two steel guide blocks at both sides of each RPV foot resists and transmits the horizontal (tangential) forces to the RPV support bracket.

(1), (2) Design details of the RPV feet will be available prior to COL application.

DCD Section 3.8.3.4.2 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-52

DCD Section 3.9.2 presents the criteria, testing procedures, and dynamic analyses used to ensure the structural and functional integrity of piping systems, mechanical equipment, reactor internals, and their supports (including supports for conduits, cable trays, and ventilation ducts) under vibratory loadings. DCD Section 3.10.3.2 describes the design approach for cable tray, and conduit supports. Although some limited information is provided in DCD Sections 3.9.2 and 3.10.3 about the design of supports for conduits, cable trays, and ventilation ducts, no information could be located that covers design criteria for conduits, cable trays, and ventilation ducts. Containment internal structures have attached conduits, cable trays, and ventilation ducts. However, DCD Section 3.8.3 does not describe the design criteria used for cable trays, conduits, and ventilation ducts. Therefore, please provide a description of the analysis and design criteria (i.e., description; applicable codes, standards, and specifications; loads and load combinations; acceptance criteria; and analysis and design procedures) used for cable trays, conduits, and ventilation ducts inside containment.

Include this information in the DCD. In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

The type and spacing of supports for Seismic Category I commodities such as cable trays, conduits, and ventilation ducts are governed by rigidity and stress. These commodities are designed to the loads, loading combinations, and allowable stresses in accordance with applicable codes, standards, and regulations consistent with C-I steel structures as shown in DCD Tables 3.8-6 and 3.8-9.

(1), (2) At this stage of the design process, detailed reports/calculations for the design of the commodities are not available.

DCD Sections 3.8.4.1.6 and 3.8.4.1.7 will be added in the next update as noted in the attached markups.

NRC RAI 3.8-53

From the information provided in Section 3.8.3 and Appendix 3G, it is not clear whether there are any other pipe rupture loads acting on containment internal structures other than the FW and RWCU breaks which induce annulus pressurization loads on the reactor shield wall. Explain whether there are any other pipe break loads acting on containment internal structures and describe the loads, models, analysis, and design approach for these loads.

Include this information in DCD Section 3.8.3 and/or Appendix 3G. In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

Pipe rupture loads contain not only annulus pressurization (AP) pressure acting on the reactor shield wall (RSW) but also the nozzle jet, jet impingement and pipe whip restraint loads as stated in DCD 3G.1.5.2.12. The AP pressure time histories were generated for the FW and RWCU breaks in the annulus between the RPV and the RSW. A steam line (SL) break being outside of the annulus does not induce AP pressure. The time histories of the nozzle jet, impingement jet and pipe whip restraint loads induced by SL, FW and RWCU breaks were calculated. They are considered not only for the reactor shield wall (RSW), but also for the RPV support bracket, diaphragm floor (DF) and vent wall (VW) structure.

Building dynamic spectral loads and displacements generated by the AP loads are considered in the design. Dynamic analyses and the results are documented in DCD Appendix 3F. Response Spectra and displacements generated by AP loads are to be used for the analysis and design of structures, systems and components (SSCs) located inside of RCCV.

(1) The applicable detailed reports/calculations that will be available for NRC audit are:

   a. 26A6558, *General Civil Design Criteria, Revision 1*, November 2005, containing pressure time histories of pressure due to FW and RWCU breaks, nozzle jet, impingement jet and pipe whip restraint loads.

   b. DC-OG-0053, *Structural Design Report for Containment Internal Structures, Revision 2*, October 2005, containing evaluation method and results for structural integrity of containment internal structures.

   c. 092-134-F-C-00008, *SRVD, LOCA & AP Dynamic Responses in RPV and RSW, Issue 1*, June 8, 2006, containing analysis and results for the response of the RPV, and the RSW to CO, CH, HVL, LCO and SRV in the SP, as well as AP in the RSW and the RPV, and the associated nozzle jet, jet impingement and pipe whip restraint loads.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-54

DCD Section 3.8.3.5.1 through 3.8.3.5.6 state that the structural acceptance criteria for each of the containment internal structures are in accordance with ANSI/AISC-690. Explain why these statements do not specify that the structural acceptance criteria for each of the containment internal structures are in accordance with Table 3.8-7, where (as noted in footnote 5 of DCD Table 3.8-7) the allowable elastic working stress (S) is the allowable stress limit specified in Part 1 of ANSI/AISC-690.

GE Response

Invoking the structural acceptance criteria for each of the containment internal structures to be in accordance with ANSI/AISC N690 means the same as in DCD Table 3.8-7.

DCD Subsections 3.8.3.4 and 3.8.3.5 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-55

DCD Section 3.8.3.7 states that testing and in-service inspection of the diaphragm floor and vent wall are discussed in Subsection 3.8.1.7. Since DCD Section 3.8.1.7 does not discuss the in-service inspection of these two structures, provide a description of the in-service inspection of the diaphragm floor and vent wall.

Include this information in DCD Section 3.8.3.7.

GE Response

The first paragraph in DCD Section 3.8.1.7.3.4 will be revised to add a sentence as follows: "The diaphragm floor and vent wall will receive a visual, VT-3, examination once during each inspection interval." This information will then be addressed in DCD Section 3.8.3.7 by reference to DCD Section 3.8.1.7.

DCD Section 3.8.1.7.3.4 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-57

DCD Section 3.8.3.6 describes the materials used for the containment internal structures. For many of these structures, several material types are listed (e.g., ASTM A572 or A709 HPS 70W). Explain whether (1) both are listed because each type is used in a different location; or (2) different material choices are available to the COL applicant. Identify and compare the key material properties of the different materials listed.

Include this information in DCD Section 3.8.3.6.

GE Response

a) RPV Bracket - The materials specified for the RPV support bracket are used depending on the thickness of each part in DCD Section 3.8.3.6.2.

b) RSW - The materials specified for the RSW are used depending on the thickness of each part in DCD Section 3.8.3.6.3.

c) Other Containment Internal Structures - The materials specified for other containment internal structures are choices available for use in construction.

The key material properties are listed in Table 3.8-57(1) below.

Table 3.8-57(1) Key Material Properties

Spec	Grade	Thickness (in)	Yield Point (ksi)	Tensile Strength (ksi)	Elongation in 8 in. (%)
A709	HPS 70W	≤4	70	85-110	19 (in 2 in.)
A572	50	≤4	50	65	18
A572	65	≤1.25	65	80	15
A516	55	≤12	30	55-75	23
A516	70	≤8	38	70-90	17
A668	Class F	7<t≤10	50	85	19 (in 2 in.)
A668	Class F	10<t≤20	48	82	19 (in 2 in.)
A668	Class G	≤12	50	80	24 (in 2 in.)
A36		≤8	36	58-80	20
A36		8<	32	58-80	20

DCD Section 3.8.3.6 will be revised in the next update as noted in the attached mark up.

NRC RAI 3.8-58

DCD Section 3.8.3.7 states that a formal program of testing and in-service inspection is not planned for the internal structures except for the diaphragm floor and vent wall. DCD Section 3.8.3.7 also states that the other internal structures are not directly related to the functioning of the containment system; therefore, no testing or inspection is performed. For the other structures, confirm that Regulatory Guide 1.160 and 10 CFR 50.65 "Maintenance Rule" requirements for structures monitoring and maintenance are applicable to the ESBWR design. If this is not the case, provide the technical basis.

Include this information in DCD Section 3.8.3.7.

GE Response

DCD Section 3.8.3.7 will be revised to read: "A formal program of testing and in-service inspection is not planned for the internal structures except the diaphragm floor, and vent wall. The other internal structures are not directly related to the functioning of the containment system; therefore, no testing or inspection is performed. However, during the operating life of the plant the condition of these structures should be monitored by the COL holder to provide reasonable confidence that the structures are capable of fulfilling their intended functions."

DCD Section 3.8.3.7 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-60

DCD Section 3.8.4 (pg 3.8-28) states that: "The main steam tunnel walls protect the RB from potential impact by rupture of the high-energy main steam pipes that extend to the Turbine Building. Thus the RB walls of the main steam tunnel are designed to accommodate the guard pipe support forces." Clarify that all high energy lines in the main steam tunnel are protected by guard pipes. If not, explain why the tunnels are only designed for "guard pipe support forces." Also, the staff notes that Section 3.6.2.4 states that the ESBWR does not require guard pipes. Clarify this discrepancy and explain where the criteria for the design of any guard pipes used in the ESBWR design is discussed in the DCD.

Include this information in DCD Section 3.8.4. In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

No guard pipes are provided in the ESBWR because the main steam and feedwater piping inside the Main Steam Tunnel from the RCCV penetrations to the seismic restraints located close to the Turbine Building comply with the break exclusion stress and fatigue limits as per BTP EMEB 3-1 of SRP 3.6.2. Therefore, the RB walls of the main steam tunnel are designed to accommodate the penetrations and pipe support forces as well as the postulated pipe break pressure loads. The postulated pipe break locations and configuration general criteria are discussed in DCD Subsection 3.6.2.1. Please see attached Figure 3.8-60(1) for further clarification on Main Steam Tunnel design.

DCD Subsection 3.8.4 will be revised in the next update as noted in the attached markup.

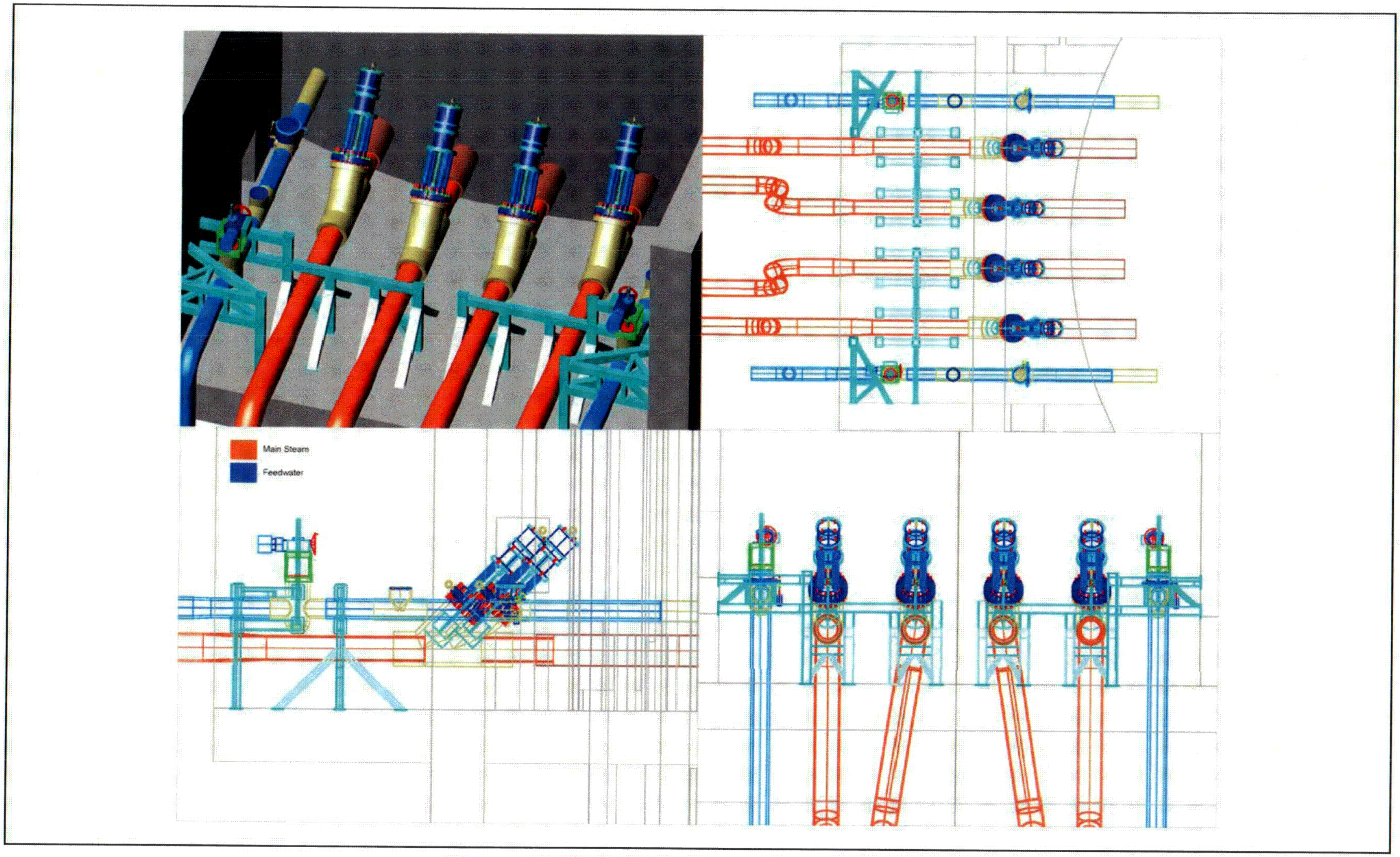


Figure 3.8-60(1) Main Steam Tunnel Overview

NRC RAI 3.8-61

DCD Section 3.8.4 (pg 3.8-28) states that Seismic Category I masonry walls are not used in the design. Explain if there are any non-safety related masonry walls used in the ESBWR design. If so, provide the criteria used to design such walls to assure that their failure does not affect any safety related structures, systems or components.

GE Response

Masonry wall construction is not used in the ESBWR design. Removable shield blocks designed to Seismic Category II acceptance criteria that provide equivalent shielding are used.

DCD Section 3.8.4 will be revised in the next update as noted in the attached markup.

DCD Figures 1.2-1 and 1.2-3 will be updated to revise "Concrete Block" to "Shield Block" in the next DCD revision.

NRC RAI 3.8-66

DCD Section 3.8.4.2 refers to Table 3.8-9 for the "applicable" documents for the design of the Reactor Building, Control Building, Fuel Building, and Radwaste Building. Table 3.8-9 lists the codes, Standards, Specifications, and Regulations Used in the Design and Construction of Seismic Category I Structures. It is noted that the title of this table includes "regulations"; however, the reference list actually includes a list of regulatory guides. For each item in Table 3.8-9, identify and explain any exceptions to codes and standards for the ESBWR design.

GE Response

In the title of DCD Table 3.8-9, "Regulations" will be changed to "Regulatory Guides".

Regarding Item 2 of DCD Table 3.8-9, ANSI/AISC N690-1994s2 (2004), in order to comply with NUREG-1503, Appendix G, NRC Position on the use of ANSI/AISC N690 (1984), for impact and impulsive loads, the ductility factors μ in Table Q1.5.8.1 are replaced with the ductility factors in Appendix A to SRP Section 3.5.3.

In addition, RG 1.54 will be added to DCD Table 3.8-9.

DCD Table 3.8-9 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-67

DCD Section 3.8.4.2.1 states that the applicable documents for the RB design are shown in Table 3.8-9, except items 4, 11, 30 and 32. With regard to the exceptions listed:

(1) Explain why there is no exception to item 3 (ASME Subsection CC) while there is an exception to item 4 (ASME Subsection NE) and item 30 (RG 1.136 for Concrete containments),

(2) Explain the exception to item 11 (2005 AISC Specification for Structural Steel Building).

GE Response

(1) As stated in DCD Section 3.8.1.1.3, structural components which are integral with the containment structure are treated the same as far as loads and loading combinations are concerned in the design. Since item 3 (ASME Subsection CC) specifies the load combinations for the containment design, it is applicable to the design of other seismic category I structures that share a common basemat with the containment structure. Items 4 and 30 have no relation to other seismic category I structures.

(2) Item 11 is excluded because the design of safety-related steel structures is performed conforming to item 2 (ANSI/AISC-N690).

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-68

DCD Section 3.8.4.2.2 states that the NRC Rules and Regulations Title 10, Chapter 1, Code of Federal Regulations, part 73.2 and 73.55 shall be met for the Control Building. These rules pertain to the physical protection of plants and materials. Explain why these rules are specifically referenced for the Control Building and are not referenced for other Category I structures. Also explain how these rules will be implemented for each category I structure.

GE Response

The physical protection of plants and materials are covered in DCD Section 13.6, Physical Security. The NRC Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations, Part 73.2 and 73.55 will be deleted from DCD Section 3.8.4.2.2.

DCD Section 3.8.4.2.2 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-70

DCD Section 3.8.4.2.5 discusses the welding and subsequent inspections of pool liners during construction. Clarify that these procedures apply to all pool liners, including the spent fuel pool liner. For the spent fuel pool liner, explain whether the liner welds will include leak chase channels to monitor any spent fuel pool leakage during operation. If so, describe the design of the system and what is expected of the COL applicant. If not, describe how the potential for spent fuel pool leakage will be monitored during operation.

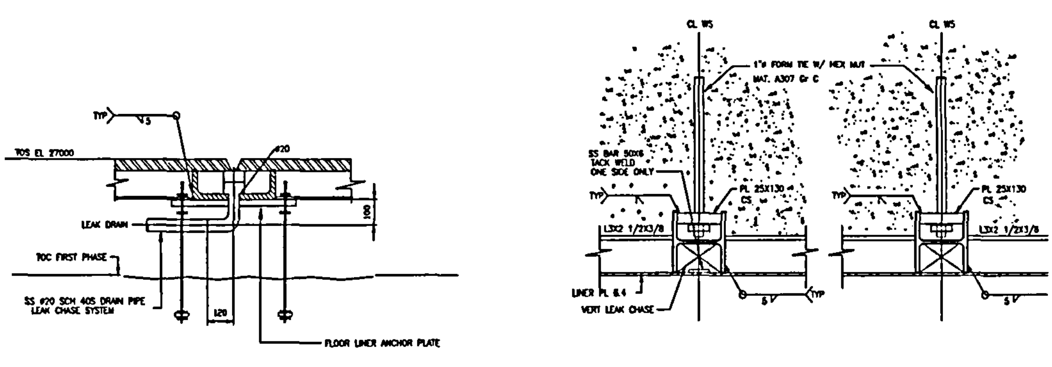
Include this information in DCD Section3.8.4.2.5.

GE Response

Liner welds of spent fuel pools are backed by leak chase channels. The leak chase channels are grouped according to the different pool areas and direct any leakage to area drains. This allows both leak detection and determination of where leaks originate. The functioning of the leak chase channels are checked prior to completion of the pool liner installation. Construction details of the location of drains and pipes that collect this leakage are not available at this time. The COL holder will determine the need for developing procedures for monitoring any potential pool leakage.

Generic examples of the leak chase channel are provided in Figure 3.8-70(1)

No DCD changes will be made in response to this RAI.



LINER FLOOR AND LEAK CHASE CHANNEL
NTS

LINER WALL WELD AND LEAK
CHASE CHANNELS DETAILS
NTS

Figure 3.8-70(1) Leak Chase Channel

NRC RAI 3.8-71

DCD Section 3.8.4.3.1.1 identifies the loads for the Reactor Building. Pa is defined as the accident pressure at the main steam tunnel due to a high energy line break. Ta is defined as the thermal effects (including To which may occur during a design accident). It is noted that the Reactor Building is structurally connected to the Containment walls at all floor elevations. The Containment structure is also supported on the same foundation as the Reactor Building. Therefore, explain why the Reactor Building is not designed for the effects of Ra, Ta, Pa, CO, CHUG, VLC and PS as defined in Section 3.8.1.3.5 for the Containment, as well as SRV loads, as defined in Section 3.8.1.3.1. Some of these loads may not have a direct effect on the Reactor Building, but since the Reactor Building supports the Containment, the loads are transmitted to the Reactor Building floors and walls. Also explain why the dynamic effects of the above loads are not considered in the design of the entire Reactor Building.

Include this information in DCD Section 3.8.4 and/or Appendix 3G. In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

DCD Section 3.8.4.3.1.1 presents only the loads that are applied to the RB directly. Other loads that are applied to the RCCV only but have some effect on the RB structures because of a common foundation mat, like P_a and T_a, are also considered in the RB design. Refer to DCD Table 3G.1-11 for an example of application.

(1) The applicable detailed report/calculation that will be available for the NRC audit is 26A6651, *RB Structural Design Report, Revision 1*, November 2005, containing the structural design details of the Reactor Building.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Section 3.8.4.3.1.1 and DCD Table 3G.1-11 will be revised in the next update as noted in the attached markups.

NRC RAI 3.8-72

Please confirm that application of the 100/40/40 method for combining directional responses is consistent with the staff-accepted method, as delineated in DG-1127. If not, provide the technical basis for the differences.

GE Response

Refer to RAI 3.7-41 for the same question. The 100/40/40 method used is consistent with DG-1127 requirements.

No DCD changes will be made in response to this RAI.

NRC RAI 3.8-74

DCD Section 3.8.4.3.3 states that accident pressure loads (Pa) do not exist for the Fuel Building. In Section 3.8.4, the DCD states that the Reactor Building and Fuel Building are built on a common foundation mat and are structurally integrated into one building. The Reactor Building is also structurally connected to the Containment walls at all floor elevations and the Containment structure is also supported on the same foundation as the Reactor Building. Therefore, explain why the fuel Building is not designed for the effects of Ra, Ta, Pa, CO, CHUG, VLC and PS, as defined in Section 3.8.1.3.5 for the Containment, as well as SRV loads, as defined in Section 3.8.1.3.1. Some of these loads may not have a direct effect on the Fuel Building, but the loads may be transmitted to the Fuel Building floors and walls. Also explain why the dynamic effects of the above loads are not considered in the design of the entire Fuel Building.

It is also noted that DCD Section 3G.3.5.2.1.1 does not define either Pa or Ta for the Fuel Building; however, Table 3G.3-4 includes Pa and Ta in two of the three selected load combinations [LOCA (1.5Pa) 72 hours and LOCA + SSE 72 hours]. Explain the LOCA loads considered in these two load combinations and correct the loads defined in Section 3G.3.5.2.1.1 and Section 3.8.4.3.3.

Include this information in DCD Section 3.8.4 and/or Appendix 3G. In addition, (1) identify the applicable detailed report/calculation (number, title, revision and date, and brief description of content) that will be available for audit by the staff, and (2) reference this report/calculation in the DCD.

GE Response

DCD Section 3.8.4.3.3 presents only the loads that are applied to the FB directly. Other loads that are applied to the RCCV only but have some effect on the FB structures because of a common foundation mat, like P_a and T_a, are also considered in the FB design. Refer to DCD Table 3G.3-4 for an example of application.

(1) The applicable detailed report/calculation that will be available for the NRC audit is 26A6655, *FB Structural Design Report, Revision 1*, November 2005.

(2) Since this information exists as part of GE's internal tracking system, it is not necessary to add it to the DCD submittal to the NRC.

DCD Appendix 3G.3.5.2.1 and DCD Table 3G.3-4 will be revised in the next update as noted in the attached markups.

NRC RAI 3.8-75

Section 3.8.4.5.1 references SRP 3.8.1 Section II.3. This appears to be an incorrect reference. Please check this section and correct as needed. If this is not an error, please explain the reference to SRP 3.8.1.

GE Response

"SRP 3.8.1 Section II.3" will be revised to read "SRP 3.8.4 Section II.3.

DCD Section 3.8.4.5.1 will be revised in the next update as noted in the attached markup.

NRC RAI 3.8-78

DCD Section 3.8.4.2 indicates that the design of the Seismic Category I Structures conform to ANSI/AISC N690-1994s2 (2004). This standard has not been formally reviewed and accepted by the staff. However, the staff has previously accepted ANIS/AISC N690-84 subject to supplemental requirements described in Appendix G of NUREG-1503 (NRC SER on ABWR). Therefore, identify all differences between ANSI/AISCN690-1994s2 (2004) and ANIS/AISC N690-84 (with NRC-accepted supplemental requirements) that affect the ESBWR design. Provide the technical basis which ensures that a comparable level of safety is achieved for each such difference between the two standards.

GE Response

In the attached table, the differences between ANSI/AISC N690-1994s2 (2004) and ANIS/AISC N690-84 (with NRC-accepted supplemental requirements) that affect the ESBWR design are compared and summarized. As shown in the table, the following items are the most important ones that affect the design of Safety-related Seismic Category I steel structures.

1. Secondary stress: One of the major supplemental requirements described in Appendix G of NUREG-1503 is that secondary stress should apply to stresses developed by temperature loading only. This concept is clarified in Q1.0.2 and is also reflected in Load Combination 9a of ANSI/AISC N690-1994s2 (2004) considered in the design of C-I steel structures of the ESBWR. Thermal stress in the Safety-related steel structures of the ESBWR is considered as secondary stress and conforms to the supplemental requirement (1) in Appendix G of NUREG-1503.
2. Reducing factor 0.9: In Q1.3.6 of ANSI/AISC N690-1994s2 (2004), the reducing factor 0.9 is used the same as the supplemental requirement in Appendix G of NUREG-1503. Safety-related steel structures of the ESBWR follow ANSI/AISC N690-1994s2 (2004) and thus conform to NRC's position given in Appendix G of NUREG-1503.
3. As shown in the attached table, the stress limit coefficients (SLC) in Table Q1.5.7.1 of ANSI/AISC N690-1994s2 (2004) are not completely the same as those of (3) in Appendix G of NUREG-1503. However, with the limitation on secondary stress to thermal stress and an additional note (c) being introduced into DCD Table 3.8-16, the intent of SLCs in NRC's position (3) of Appendix G to NUREG-1503 is addressed. Safety-related steel structures of the ESBWR follow ANSI/AISC N690-1994s2 (2004) and thus conform to the intent of NRC's position (3) given in Appendix G of NUREG-1503.

4. According to Appendix G of NUREG-1503, the ductility factors in Table Q1.5.8.1 should not be used in load combinations 9, 10, and 11. For impact and impulsive loads, the provisions of item II.2 of Appendix A to SRP Section 3.5.3 should be substituted for the ductility factors in Table Q1.5.8.1. For the design of ESBWR Safety-related steel structures, the ductility factors in Table Q1.5.8.1 are used with the condition in Section Q1.5.7.2 only. For impact and impulsive loads, the provisions of item II.2 of Appendix A to SRP Section 3.5.3 are to be used.

DCD Tables 3.8-9 and 3.8-16 will be revised in the next update as noted in the attached markups.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-16)
(1) Q1.0.2: Secondary stress should apply to stresses developed by temperature loading only.	Q1.0.2: A secondary stress is any normal stress or shear stress developed by the constraint of adjacent material or by self-constraint of the structure.	Q1.0.2: A secondary stress is any normal stress or shear stress developed by the constraint of adjacent material or by self-constraint of the structure	Q1.0.2: Secondary stress is a stress developed by the self-constraint of a structure rather than from external loads. The basic characteristic of a secondary stress is that it is self-limiting.	Thermal stress is considered as secondary stress.
(2) In Q1.3.6, add: a) When any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with other loads. Otherwise, the coefficient for that load should be taken as zero. b) Where the structural effects of differential settlement are present, they should be included with the dead load D. c) For structures or structural components subjected to hydrodynamic loads resulting from a loss-of-coolant accident (LOCA) and/or safety/relief valve (SRV) actuation, the consideration of such loads should be as indicated in the appendix to Standard Review Plan (SRP) Section 3.8.1. Any fluid structure interaction associated with these hydrodynamic loads and those from the postulated earthquake(s) should be taken into account.	No equivalent requirement is given in Q1.3.6.	No equivalent requirement is given in Q1.3.6.	In Q1.3.6, add: a) When any load reduces the effects of other loads and if it can be demonstrated that the load is always present or occurs simultaneously with other loads, the corresponding coefficient for that load shall be taken as 0.9. Otherwise, the coefficient for that load should be taken as zero. b) No equivalent requirement given in Q1.3.6. c) See Q1.3.7.	a) Same as N690-1994s2. b) Same as NUREG-1053. c) Not applicable.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-16)
(3) The stress limit coefficients (SLC) for compression in Table Q1.5.7.1 should be as follows: 1.6 instead of 1.7 in load combination 11; 1.4 instead of 1.6 in load combinations 7, 8 and 9; 1.3 instead of 1.5 (stated in footnote (c)) for load combinations 2, 5 and 6.	The stress limit coefficients (SLC) for compression in Table Q1.5.7.1 are as follows: • 1.7 in load combination 11. • 1.6 in load combinations 7, 8 and 9 • 1.5 (stated in footnote (c)) for load combinations 2, 5 and 6.	Same as AISC N690-1984	Same as AISC N690 -1984 except the following: (i) Load Combination 9a. D+L+Ta+Pa with stress limit coefficient 1.6 is added in the Abnormal Category. (ii) Note j, "This load combination is to be used when the global (non-transient) sustained effects of Ta are considered." is added to Load Combination 9(a). Note k, "The stress limit coefficient where axial compression exceeds 20% of normal allowable, shall be 1.5 for load combination 7,8,9,9a and 10 and 1.6 for load combination 11.	Same as N690-1994s2.
(4) The following note should be added: For constrained (rotation and/or displacement) members supporting safety-related structures, systems, and components (SSCs), the stresses under load combinations 9, 10 and 11 should be limited to those allowed in Table Q1.5.7.1 as modified by Provision 3 above. The ductility factors of Table Q1.5.8.1 (or Provision 5 below) should not be used in these cases.	No equivalent requirement is given in Table Q1.5.8.1.	No equivalent requirement is given in Table Q1.5.8.1.	Same as above	Same as N690-1994s2. Ductility factors in Table Q1.5.8.1 are used with the condition in Section Q1.5.7.2 only.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-16)
(5) For ductility factors μ in Sections Q1.5.7.2 and Q1.5.8, the provisions of Item II.2 of Appendix A to SRP Section 3.5.3 should be substituted for the ductility factors in Table Q1.5.8.1.	Ductility factors in Table Q1.5.8.1 are different from those in Appendix A to SRP Section 3.5.3.	Ductility factor for elements in uniform compression due to bending in Table Q1.5.8.1 of N690 (1984 edition) is deleted in Table Q1.5.8.1 of N690 (1994 edition).	Q1.5.8 DESIGN BASED ON DUCTILITY AND LOCAL EFFECTS - In subparagraph a, delete Ta from the list of load effects. In the title of Table Q1.5.8.1, replace "EXTREME AND ABNORMAL LOADS' with "IMPACTIVE AND IMPULSIVE LOADS".	Same as N690-1994s2. Ductility factors in Appendix A to SRP Section 3.5.3 are substituted for the ductility factors in Table Q1.5.8.1 for impact and impulsive loads.
(6) In load combination 9 of Section Q2.1, the load factor applied to load Pa should be 1.5/1.1»1.37, instead of 1.25.	In load combination 9 of Section factor applied to load Pa is 1.25.	In load combination 9 of Section W2.1, the load factor applied to load Pa is 1.25.	No information is available	Plastic design is not used. Q2.1 is not applicable to ESBWR.

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-16)
(7) Sections Q1.24 and Q1.25.10 should be supplemented with the following requirements regarding the painting of structural steel: Shop painting is to be in accordance with Section M3 of load and resistance factor design (LRFD) specifications (American Institute of Steel Construction, "Load and Resistance Factor Design for Structural Steel Buildings and Its Commentary," Chicago, IL, 1986). All exposed areas after installation are to be field painted (or coated) in accordance with the applicable portion of Section M3 of the LRFD specification. The quality assurance requirements for the painting (or coating) of structural steel are to be in accordance with ANSI N101.4 (American Institute for Chemical Engineers, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities," New York, 1972) as endorsed by Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water Cooled Nuclear Power Plants," Revision 0.	Q1.24 SHOP PAINTING Shop painting shall be as specified by the Engineer. Q1.25.10 FIELD PAINTING Field painting shall be as specified by the Engineer.	Q1.24 SHOP PAINTING Shop painting shall be as specified by the Engineer. Q1.25.10 FIELD PAINTING Field painting shall be as specified by the Engineer	Q1.24 SHOP PAINTING Q1.24.1 GENERAL REQUIREMENTS Shop painting and surface preparation shall be in accordance with the provisions of the Code of Standard Practice of the American Institute of Steel Construction, Inc. Unless otherwise specified, steelwork that will be concealed by interior building finish or will be in contact with concrete need not be painted. Unless specifically excluded, all other steelwork shall be given one coat of shop paint. The quality assurance requirements for painting (or coating) of structural steel shall be in accordance with ASTM D3843 as endorsed by Regulatory Guide 1.54. Q1.24.2 INACCESSIBLE SURFACES Except for contact surfaces, surfaces inaccessible after shop assembly shall be cleaned and painted prior to assembly, if required by the design documents. Q1.24.3 CONTACT SURFACES Paint is permitted unconditionally in bearing-type connections. For slip-critical connections, the faying surface requirements shall be in accordance with the RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts, paragraph 3.2.2.	Same as N690-1994s2

NUREG-1503, Appendix G, NRC Positions on the use of AISC N690-1984	N690-1984	N690-1994	N690-1994s2	ESBWR (DCD Table 3.8-16)
			Q1.24.4 FINISHED SURFACE Machine-finished surfaces shall be protected against corrosion by a rust-inhibiting coating that can be removed prior to erection, or which has characteristics that make removal prior to erection unnecessary. Q1.24.5 SURFACES ADJACENT TO FIELD WELDS Unless otherwise specified in the design documents, surfaces within 2 in. of any field weld location shall be free of materials that would prevent proper welding or produce toxic fumes during welding. Q1.25.10 FIELD PAINTING Replace current text with the following: Responsibility for touch-up painting, cleaning and field-painting shall be allocated in accordance with accepted local practices, and this allocation shall be set forth explicitly in the design documents.	

NRC RAI 3.8-98

DCD Section 3.8.5.5 refers to DCD Section 3.7.2.14 for a description of the overturning analysis methodology. The staff has previously requested additional information on this subject in RAI 3.7-48. Revise DCD Section 3.8.5.5 if needed as a result of any changes made to Section 3.7.2.14 in response to RAI 3.7-48.

GE Response

Please refer to response to RAI 3.7-48.

Table 3.2-1

Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
T62 Containment Monitoring System						
1. Safety-related portions of System	2/3	CV, RB, CB	—	B	I	Containment isolation function is safety class 2, rest of safety-related functions are safety class 3.
2. Nonsafety-related portions of system	N	CV, RB, CB	—	E	NS	
T64 Environmental Monitoring System	N	OL	—	E	NS	
U STRUCTURES AND SERVICING SYSTEMS						
U31 Cranes, Hoists, and Elevators						
1. Reactor building cranes, fuel building crane	N	RB, FB	—	E	II	**Cranes** — The reactor building and fuel building cranes are designed to maintain their position and hold up their loads under conditions of an SSE.
2. Upper and lower drywell servicing hoists and cranes	N	CV	—	E	I	
3. Main steam tunnel servicing hoists and cranes	N	OL	—	E	NS	
4. Special service rooms hoists and cranes	N	RB, TB, FB, RW	—	E	NS	
5. Elevators	N	RB, TB, FB, CB, RW	—	E	NS	
U36 Electrical Building HVAC	N	EB	—	E	NS	
U37 Service Building HVAC	N	SB	—	E	NS	
U38 Radwaste Building HVAC	N	RW	—	E	NS	

Table 3.2-1

Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
U39 Turbine Building HVAC	N	TB	—	E	NS	
U40 Reactor Building HVAC						
1. Building isolation dampers	3	RB	—	B	I	
2. Controls associated with the isolation dampers	3	RB	—	B	I	
3. Other system components	N	RB	—	E	II	
U41 Other Building HVAC	N	OL	—	E	NS	
U42 Potable Water and Sanitary Waste System	N	CB, SB, EB, RB, OO	—	E	NS	
U43 Fire Protection System (FPS)						
1. Non-seismic yard piping loop and valves including supports	N	OO, OL	D	E	NS	**Fire Protection System** — A quality assurance program meeting the guidance of NRC Branch Technical Position SPLB 9.5-1 (NUREG-0800) is applied to the protection system. Also, special seismic qualification requirements are applied.
2. Seismic category I piping loop and valves including supports	N	OO, RB, CB, FB	C	E	I	Same as above.
3. Fire water storage tank	N	OO	C	E	I	Same as above.
4. Fire pump enclosure	N	OO	—	E	II	Same as above.
5. Seismic category I pump including diesel-engine drive	N	OO	C	E	I	Same as above.
6. Booster pumps	N	RB	C	E	I	Same as above.
7. Motors for seismic category I pumps	N	OO,RB	—	E	I	Same as above.
8. Other pumps and motors	N	OO	D	E	NS	Same as above.

Table 3.2-1
Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
U97 Fuel Building Structure	3/N	FB	—	B	I/II	Main building is SC I. HVAC Penthouse, Stair towers and elevator shafts are SC II.
U98 Fuel Building HVAC						
1. Building isolation dampers	3	FB	—	B	I	
2. Ducting penetrating fuel building boundary	3	FB	—	B	I	
3. Controls associated with the isolation dampers	3	FB	—	B	I	
4. Other system components	N	FB	—	E	II	
U99 Stack	N	OO	—	E	NS	
W INTAKE STRUCTURE AND SERVICING EQUIPMENT						
W12 Intake and Discharge Structures	N	OO	—	E	NS	
W24 Cooling Tower	N	OO	—	E	NS	
W32 Screen Cleaning Facility	N	OO	—	E	NS	
W33 Screens, Racks, and Rakes	N	OO	—	E	NS	
W41 Intake Structure Power Supply	N	OO	—	E	NS	
Y YARD STRUCTURES AND EQUIPMENT						
Y12 Roads and Walkways	N	OO	—	E	NS	
Y21 Tanks and Equipment Pads	N	OO	—	E	NS	Some tanks in the yard area belong to other systems (e.g., fire water storage tank in U43) and have different classifications.
Y41 Station Water System	N	OO	—	E	NS	
Y46 Cathodic Protection System	N	OO	—	E	NS	
Y47 Meteorological Observation System	N	OO	—	E	NS	

Table 3.2-1

Classification Summary

Principal Components[1]	Safety Class.[2]	Location[3]	Quality Group[4]	QA Req.[5]	Seismic Category[6]	Notes
Y51 Yard Miscellaneous Drain System	N	OO	—	E	NS	
Y52 Oil Storage and Transfer System	N	OO	—	E	NS	
Y53 Chemical Storage and Transfer System	N	OO	—	E	NS	
Y71 Piping Duct	N	OL	—	E	NS	Typical classifications for piping ducts in the yard area. Classification of individual piping ducts shall match the classification of the pipe they carry.
Y72 Cable Duct	N	OL	—	E	NS	Typical classifications for cable ducts in the yard area. Classification of individual cable ducts shall match the classification of the cables they carry.
Y86 Site Security	N	ALL	—	E	NS	

Notes:

(1) Principal components: A module is an assembly of interconnected components that constitute an identifiable device or piece of equipment. For example, electrical modules include sensors, power supplies, and signal processors; and mechanical modules include turbines, strainers, and orifices.

(2) Safety Class: 1, 2, 3 or N are designations for safety-related or nonsafety-related as discussed in Subsection 3.2.3.

(3) Location codes:

ALL = All locations

CV	=	Containment Vessel	RW	=	Radwaste Building
CB	=	Control Building	CP	=	Circulating Water Pump House
RB	=	Reactor Building	SF	=	Service Water Building
OO	=	Outdoors Onsite	TB	=	Turbine Building

3.7 SEISMIC DESIGN

For seismic design purposes, all structures, systems, and components of the ESBWR standard plant are classified into Seismic Category I (C-I), Seismic Category II (C-II), or Non-Seismic (NS) in accordance with the requirements to withstand the effects of the Safe Shutdown Earthquake (SSE) as defined in Section 3.2. For those C-I and C-II structures, systems and components in the reactor building complex, the effects of other dynamic loads caused by reactor building vibration (RBV) caused by suppression pool dynamics are also considered in the design. Although this section addresses seismic aspects of design and analysis in accordance with Regulatory Guide 1.70, the methods of this section are also applicable to RBV dynamic loadings, unless noted otherwise. The method of combination of peak dynamic responses to seismic and RBV loads is the Square Root of the Sum of the Squares (SRSS) in accordance with NUREG-0484 Revision 1. For reinforced concrete structures the section forces or stresses due to each dynamic load are combined in the most conservative manner by systematically varying the sign (+ or -), equivalent to the absolute sum method.

The safe shutdown earthquake (SSE) is that earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology, seismology, and specific characteristics of local subsurface material. It is the earthquake that produces the maximum vibratory ground motion for which Seismic Category I structures, systems and components (SSC) are designed to remain functional and within applicable stress, strain, and deformation limits. These systems and components are those necessary to ensure the following:

- The integrity of the reactor coolant pressure boundary (RCPB);
- The capability to shut down the reactor and maintain it in a safe condition; or
- The capability to prevent or mitigate the consequences of accidents which could result in potential offsite exposures comparable to the applicable guidelines exposures set forth in 10 CFR 100 (10 CFR 50.34(a)).

ESBWR response to an earthquake up to SSE may achieve shutdown of the reactor and maintenance of it in a safe condition using the Automatic Depressurization System and Gravity Driven Cooling System as described in the Probabilistic Risk Assessment. In this case, depressurization is accomplished in part with Depressurization Valves that remain open in order for the Gravity Driven Cooling System and the Passive Containment Cooling System to perform their safety functions.

Seismic Category II (C-II) includes all plant SSC which perform no safety-related function, and whose continued function is not required, but whose structural failure or interaction could degrade the functioning of a Seismic Category I structure, system or component to an unacceptable safety level, or could result in incapacitating injury to occupants of the control room. Thus, this category includes the SSC whose structural integrity, not their operational performance, is required. Seismic Category II SSC are designed such that the SSE would not cause unacceptable structural interaction or failure. For fluid systems, this requires an appropriate level of pressure boundary integrity when located near sensitive equipment. The methods of seismic analysis and design acceptance criteria for C-II SSC are the same as C-I; however, the procurement, fabrication and construction requirements for C-II SSC are in

(5) The containment top slab from the drywell head opening to the outside diameter of the containment.

The above are included in the ASME Code jurisdiction boundary for design, material, fabrication, inspection, testing, stamping, etc., requirements of the code. However, any other structural components which are integral with the containment structure are treated the same as the containment as far as loads and loading combinations are concerned in the design. Similarly, the RB floor slabs that are integrated with the containment are not included in the ASME Code jurisdictional boundaries, but are treated the same as the containment only as far as loads and load combinations are concerned.

The vent wall and diaphragm floor slab, which partition the containment into drywell and suppression chamber, are not part of the containment boundary. The vent wall and the diaphragm floor slab, steel structures filled with concrete, are designed according to codes given in Subsection 3.8.3.

Those portions of the structure outside the indicated Code jurisdictional boundary are designed, analyzed and constructed as indicated in Subsection 3.8.4. The analytical model includes the containment, RB, FB and all the integrally connected structures and therefore includes continuity effects in the analysis.

3.8.1.2 Applicable Codes, Standards, and Specifications

The design, fabrication, construction, testing, and in-service inspection of the concrete containment conforms to the applicable codes, standards, specifications, and regulations listed below, except where specifically stated otherwise.

3.8.1.2.1 Regulations

(1) Code of Federal Regulations, Title 10, Energy, Part 50, "Domestic Licensing of Production and Utilization Facilities."

(2) Code of Federal Regulations, Title 10 - Energy, Part 100, Reactor Site Criteria, (10CFR100), including Appendix A thereto, "Seismic and Geologic Siting Criteria for Nuclear Power Plants."

3.8.1.2.2 Construction Codes of Practice

Table 3.8-9 item 3.

3.8.1.2.3 General Design Criteria, Regulatory Guides, and Industry Standards

(1) 10CFR50, Appendix A, "General Design Criteria for Nuclear Power Plants", Criteria 1, 2, 4, 16 and 50. Conformance is discussed in Section 3.1.

(2) Table 3.8-9 Item 29, 30, 31 and 33

(3) Industry Standards

Only nationally recognized industry standards such as those published by the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) as referenced by the Applicable Codes, Standards, and Regulations are used.

3.8.1.7.3.3 Preservice Examination

The preservice examinations shall be performed prior to plant startup but after the Structural Integrity Pressure Test. Visual examinations shall be performed after the application of any required protective coatings. The preservice examinations shall include those examinations listed in ASME Section XI, Table IWE-2500-1, IWL-2510 and Table IWL-2500-1.

3.8.1.7.3.4 Inservice Inspection Schedule

The inservice inspection interval for Class MC components and metallic shell and penetration liners of Class CC components and their supports shall conform to Inspection Program B as described in ASME Section XI, IWE-2412. Except where deferral is permitted by ASME Section XI, IWE-2500-1, the percentages of examinations completed within each period of the interval shall correspond to Table IWE-2412-1. The diaphragm floor and vent wall will receive a visual, VT-3, examination once during each inspection interval.

The inservice inspection of Class CC reinforced concrete shall be performed at 1, 3, and 5 years after the completion of the Structural Integrity Pressure Test and every 5 years thereafter in accordance with ASME Section XI, IWE-2410 and Table IWE-2500-1.

3.8.1.7.3.5 Pressure Tests

The pressure testing (leakage testing) of the Containment Structure shall be conducted in accordance with 10 CFR 50, Appendix J. In addition, the leakage test requirements of ASME Section XI, IWE-5000 and IWL-5000 shall apply following repair/replacement activities as defined by the ASME Code.

3.8.1.7.3.6 Qualification of Examination Personnel

Personnel performing preservice and inservice examinations of the containment system shall be qualified in accordance with the applicable requirements of the ASME Section XI. Personnel performing visual examination types VT-1 and VT-3 in accordance with 3.8.1.7.3.7 and ultrasonic examination shall be qualified in accordance with Section XI, IWA-2300. Personnel performing detailed visual examination and general visual examination of concrete shall be qualified in accordance with IWA-2300 to perform examinations as described in IWE-2300.

3.8.1.7.3.7 Visual Examination Methodology

Visual examination types VT-1 and VT-3 shall be conducted in accordance with ASME Section XI, IWA-2210. When performing examinations remotely, the requirements of Table IWA-2210-1 may be modified in order to extend maximum specified direct examination distance and decrease the minimum illumination, provided that the conditions or indications for which the examination is being conducted can be detected at the chosen distance and illumination.

3.8.1.7.3.8 Visual Examination of Surfaces

The type VT-1 examination shall be used to conduct the detailed examination required for visible containment surfaces requiring augmented examination in accordance with ASME Section XI, Table IWE-2500-1, Examination Category E-C, Item E4.11. The type VT-3 examination shall be used to conduct the general visual examinations required for wetted surfaces of submerged areas and accessible surfaces of BWR ventilation systems as required by Table IWE-2500-1, The equipment hatches and covers are entirely supported by the RCCV.

3.8.2.1.3 Penetrations

In addition to the personnel airlocks, equipment hatches and drywell head, other steel components of the concrete containment vessel include piping and electrical penetrations. The major piping penetrations are associated with main steam and feedwater lines. Electrical penetrations are described in Subsection 8.3.3.7. A summary of various containment penetrations is given in Section 6.2. The state of stress and behavior of the containment wall around these openings is determined by the use of analytical numerical techniques. The analysis of the area around the penetrations consists of a three-dimensional finite element analysis with boundaries extending to a region where the discontinuity effects of the opening are negligible.

The RCCV penetrations are categorized into two basic types. These types differ with respect to whether the penetration is subjected to a hot or cold operational environment.

The cold penetrations pass through the RCCV wall and are embedded directly in it. The hot penetrations do not come in direct contact with the RCCV wall but are provided with a thermal sleeve, which is attached to the RCCV wall. The thermal sleeve is attached to the process pipe at distance from the RCCV wall to minimize conductive heat transfer to the RCCV wall. With regard to the local areas of concrete around high energy penetrations, thermal analyses have been carried out to demonstrate that concrete temperature limits in ASME Section III, CC-3440 are satisfied. In all cases the concrete temperature is lower than 93°C (200°F) for normal operation, and lower than 177°C (350°F) for accident condition. The sleeve length for hot penetrations is designed to meet these temperature requirements.

3.8.2.1.4 Drywell Head

A 10,400 mm diameter opening in the RCCV upper drywell top slab over the RPV is covered with a removable steel torispherical drywell head, which is part of the pressure boundary. This structure is shown in the general arrangement drawings in Appendix 3G Subsection 3G.1.5.4.1.4. The drywell head is designed for removal during reactor refueling and for replacement prior to reactor operation using the Reactor Building crane. One pair of mating flanges is anchored in the drywell top slab and the other is welded integrally with the drywell head. Provisions are made for testing the flange seals without pressurizing the drywell.

There is water in the reactor well above the drywell head during normal operation. The height of water is 6.7 m. Cladding thickness is so determined that it results in negligible stress in the base metal in accordance with ASME NE-3122.3 requirements.

There are six (6) support brackets attached to the inner surface of the drywell head circumferentially to support the head on the operating floor during refueling. These support brackets have no stiffening effect and do not resist loads when the head is in the installed configuration.

3.8.2.2 Applicable Codes, Standards, and Specifications

3.8.2.2.1 Codes and Standards

In addition to the codes and standards specified in Subsection 3.8.1.2.2, the following codes and standards apply:

3.8.3.1.4 Vent Wall

The vent wall structure is made up of two concentric carbon steel cylindrical plates connected together by vertical web plates at 15 degrees on centers. The cylindrical structure has an inner and outer diameter of 13.2m and 16.7m respectively with overall height of 12.85m. The vent wall structure is anchored at the bottom into the RPV pedestal and is restrained at the top by the diaphragm floor at elevation 17500.

The cylindrical annulus carries twelve 1.20m O.D. vent pipes and twelve SRV discharge pipes with sleeves, from the drywell into the suppression pool; and three lines of the drywell cooling system. The space in the cylindrical annulus is filled with concrete. The wetted surface of the outer cylinder is covered with stainless steel cladding to prevent corrosion.

3.8.3.1.5 Gravity Driven Cooling System (GDCS) Pool

There are three GDCS pools supported on top of the diaphragm floor.

The pools on one side are contained by the RCCV wall and on the other side by walls made of structural steel.

The GDCS pool walls away from the RCCV are made of carbon steel plates lined with stainless steel cladding and backed up with vertical and horizontal steel structural framing system.

3.8.3.1.6 Miscellaneous Platforms

Miscellaneous platforms are designed to allow access and to provide support for equipment and piping. The platforms consist of steel beams and open grating to facilitate movement of air and liquids in case of pipe breaks. Platforms are classified as Seismic Category I (C-I) structures when they support safety-related functions. Otherwise they are classified as Seismic Category II (C-II). Similarly, other miscellaneous structural components inside containment that do not support safety-related functions are classified as C-II.

3.8.3.2 Applicable Codes, Standards, and Specifications

The design of the concrete and steel internal structures of the containment conform to the applicable codes, standards, and specifications and regulations listed in Table 3.8-6 except where specifically stated otherwise.

Structure or Component	Specific Reference Number in Table 3.8-6
Diaphragm Floor	1-12, 15-20
RPV Support Bracket	15-20
Vent wall	1-12, 15-20
Reactor Shield Wall	15-20
GDCS Pool Wall	15-20

Structure or Component	Specific Reference Number in Table 3.8-6
Miscellaneous Platforms	15-20

Anchorage of steel internal structures complies with Regulatory Guide 1.199.

3.8.3.3 Loads and Load Combinations

3.8.3.3.1 Load Definitions

The loads and applicable load combinations for which a containment internal structure is designed depend on the conditions to which the particular structure is subjected.

The containment internal structures are designed in accordance with the loads described in Subsection 3.8.1.3. These loads and the effects of these loads are considered in the design of all internal structures as applicable. The reactor shield wall is also designed to the Annulus Pressurization (AP) loads, which are loads and pressures directly on the reactor shield wall caused by a rupture of a pipe within the reactor vessel shield wall annulus region.

3.8.3.3.2 Load Combination

The load combinations and associated acceptance criteria for steel internal structures of the containment are listed in Table 3.8-7.

3.8.3.4 Design and Analysis Procedures

The design of steel internal structures is performed in accordance with the general practice of the AISC-N690. See Table 3.8-7 for more details. The effects of concrete cracking of the containment structure on the accidental thermal stresses in the containment internal structures are accounted for in the form of thermal ratios as described in Subsection 3.8.1.4.1.3.

3.8.3.4.1 Diaphragm Floor

The diaphragm is included in the finite-element model described in Subsection 3.8.1.4.1.1. The design and analysis is based on the elastic method. All loads are resisted by the integral action of the top plate, bottom plate and support beams. The radial support beams are welded to the diaphragm floor, so they form an integral structure.

3.8.3.4.2 RPV Support Bracket

The RPV support bracket is included in the finite-element model described in Subsection 3.8.1.4.1.1.

The design and analysis is based on the elastic method. All loads from RPV support and RSW are resisted by the integral action of eight (8) separate brackets located separately. In order to provide a low friction coefficient (≈ 0.15) that minimizes the resistance to sliding in the RPV foot/RPV support bracket interface, bearing plates of Lubron alloy GA50 are placed between the sliding components. Therefore, there are no significant thermal expansion loads from the RPV supports acting on the RPV support brackets.

Two steel guide blocks at both sides of each RPV foot resists and transmits the horizontal (tangential) forces to the RPV support bracket.

3.8.3.4.3 Reactor Shield Wall

The reactor shield wall is included in the finite-element model described in Subsection 3.8.1.4.1.1. The design and analysis is based on the elastic method. All loads including those from the RPV stabilizer are resisted by the thick steel cylinder supported by the RPV support bracket.

3.8.3.4.4 Vent Wall

The vent wall is included in the finite-element model described in Subsection 3.8.1.4.1.1.

The design and analysis is based on the elastic method. All loads are resisted by the integral action of the inner and outer steel cylinders with connecting ribs.

3.8.3.4.5 Gravity Driven Cooling System (GDCS) Pool

The GDCS pool wall is included in the finite-element model described in Subsection 3.8.1.4.1.1.

The design and analysis is based on the elastic method. All loads are resisted by the integral action of the wall plate and support beams.

3.8.3.4.6 Miscellaneous Platforms

The miscellaneous platforms are considered as additional mass in the finite-element model described in Subsection 3.8.1.4.1.1. The platform design is based on the elastic method.

3.8.3.5 Structural Acceptance Criteria

3.8.3.5.1 Diaphragm Floor

The structural acceptance criteria for the diaphragm floor are in accordance with ANSI/AISC-N690. See Table 3.8-7 for more details.

3.8.3.5.2 RPV Support Bracket

The structural acceptance criteria for the RPV support bracket are in accordance with ANSI/AISC-N690. See Table 3.8-7 for more details.

3.8.3.5.3 Reactor Shield Wall

The structural acceptance criteria for the reactor shield wall are in accordance with ANSI/AISC-N690. See Table 3.8-7 for more details.

3.8.3.5.4 Vent Wall

The structural acceptance criteria for the vent wall are in accordance with ANSI/AISC-N690. See Table 3.8-7 for more details.

3.8.3.5.5 Gravity Driven Cooling System (GDCS) Pool

The structural acceptance criteria for the GDCS pool are in accordance with ANSI/AISC-N690.

3.8.3.5.6 Miscellaneous Platforms

The structural acceptance criteria for safety-related platforms are in accordance with ANSI/AISC-N690. See Table 3.8-7 for more details. The same criteria are used for nonsafety-related platforms for design purposes only.

3.8.3.6 Materials, Quality Control, and Special Construction Techniques

3.8.3.6.1 Diaphragm Floor

The materials conform to all applicable requirements of ANSI/AISC N690 and ACI 349 and comply with the following:

Item	Specification
Top and bottom plate	ASTM A572 or A709 HPS 70W
Support beam	ASTM A572 or A709 HPS 70W
Internal stiffeners	ASTM A572 or A709 HPS 70W
Concrete fill	$f'_c = 34.5$ Mpa
Stainless cladding for wetted surface of top plate	ASTM A-240 Type 304L

Different material choices are available from the specifications listed above.

3.8.3.6.2 RPV Support Bracket

The steel plate materials conform to all applicable requirements of ANSI/AISC-N690 and comply with ASTM A516 or A709 HPS 70W. Materials are chosen depending on the thickness of each part.

3.8.3.6.3 Reactor Shield Wall

The materials conform to all applicable requirements of ANSI/ASIC N690 and comply with the following:

Materials are chosen depending on the thickness of each part.

Item	Specification
Cylinder Plate	ASTM A516 or ASTM A668 or A709 HPS 70W

Different material choices are available from the specification listed above.

3.8.3.6.4 Vent Wall

The materials conform to all applicable requirements of ANSI/AISC N690 and ACI 349 and comply with the following:

Item	Specification
Inner and outer cylinders (excluding the portions submerged in the suppression pool)	ASTM A572 or A709 HPS 70W
Internal stiffeners	ASTM A572 or A709 HPS 70W
Concrete fill	f'_c = 34.5 Mpa
Outer shell submerged in the suppression pool	ASTM A572 or A709 HPS 70W with A-240 Type 304L clad
Vent Pipe	ASTM A-240 Type 304L

Different material choices are available from the specifications listed above.

3.8.3.6.5 Gravity Driven Cooling System (GDCS) Pool

The materials conform to all applicable requirements of ANSI/AISC N690 and comply with the following:

Item	Specification
Pool wall plate	ASTM A572 or A709 HPS 70W with A-240 Type 304L Clad
Structural support beam	ASTM A572 or A709 HPS 70W, ASTM A572 or A709 HPS 70W with A-240 Type 304L Clad

Different material choices are available from the specifications listed above.

3.8.3.6.6 Miscellaneous Platforms

The materials conform to all applicable requirements of ANSI/AISC N690 for safety related and AISC-ASD or AISC-LFRD for nonsafety-related and comply with the following:

Item	Specification
Structural steel and connections	ASTM A36
High strength structural steel plates	ASTM A572
Bolts, studs, and nuts (dia.>19mm)	ASTM A325
Bolts, studs, and nuts (dia.≤ 19mm)	ASTM A307

3.8.3.7 Testing and In-service Inspection Requirements

A formal program of testing and in-service inspection is not planned for the internal structures except the diaphragm floor, and vent wall. The other internal structures are not directly related to the functioning of the containment system; therefore, no testing or inspection is performed.

However, during the operating life of the plant the condition of these structures should be monitored by the COL holder to provide reasonable confidence that the structures are capable of fulfilling their intended functions.

Testing and in-service inspection of the diaphragm floor and vent wall are discussed in Subsection 3.8.1.7.

3.8.3.8 Welding Methods and Acceptance Criteria for Structural and Building Steel

Welding activities are performed with written procedures, combining with the requirements of the American Institute of Steel Construction (AISC) Manual of Steel Construction. The visual acceptance criteria comply with American Welding Society (AWS) Structural Welding Code D1.1 and Nuclear Construction Issue Group (NCIG) Standard, "Visual Weld Acceptance Criteria for Structural Welding at Nuclear Plants", NCIG-01.

3.8.4 Other Seismic Category I Structures

Other Seismic Category I structures which are not inside the containment and which constitute the ESBWR Standard Plant are Reactor Building (RB), Control Building (CB), Fuel Building (FB) and Emergency Breathing Air System (EBAS) Building. Figure 1.1-1 shows the spatial relationship of these buildings. Although the Radwaste Building (RW) that houses non safety-related facilities is not a Seismic Category I structure, it is designed to meet requirements as defined in Regulatory Guide 1.143 under Safety Class RW-IIa. The RB and FB are built on a common foundation mat and structurally integrated into one building. The other structures in close proximity to these structures are the Turbine Building and Service Building. They are structurally separated from the other ESBWR Standard Plant buildings.

Among the Seismic Category I structures within the ESBWR Standard Plant, other than the containment structure, only the RB contains certain rooms that have high-energy pipes, and therefore these rooms are more structurally demanding. The main steam tunnel walls protect the RB from potential impact by rupture of the high-energy main steam pipes that extend to the Turbine Building. Thus the RB walls of the main steam tunnel are designed to accommodate the pipe support forces and the environmental conditions during and after the postulated high-energy pipe break.

The ESBWR Standard Plant does not contain underground Seismic Category I pipelines or masonry wall construction.

The COL Applicant shall identify Seismic Category I structures besides those identified in Section 3.8 for the Nuclear Island. See Subsection 3.8.6.4 for COL information.

3.8.4.1 Description of the Structures

3.8.4.1.1 Reactor Building Structure

Key dimensions of the Reactor Building (RB) are summarized in Table 3.8-8.

The FB houses the spent fuel pool facilities and their supporting system and HVAC equipment. The FB is a Seismic Category I structure except for the penthouse that houses HVAC equipment. The penthouse is a Seismic Category II structure.

The FB is a reinforced concrete box type shear wall structure consisting of walls and slabs and is supported on a foundation mat. Concrete and/or steel framing is composite with a concrete slab and is used to support the slabs for vertical loads. The FB is a shear wall structure designed to accommodate all seismic loads with its walls and connected floors. Therefore, frame members such as beams or columns are designed to resist vertical loads and to accommodate deformations of the walls in case of earthquake conditions.

The summary stress report for the FB is in Appendix 3G Subsection 3G.3. This report contains a description of the FB, the loads, load combinations, reinforcement stresses, and concrete reinforcement details for the basemat, seismic walls, and floors.

3.8.4.1.4 Emergency Breathing Air System (EBAS) Building

The Emergency Breathing Air System (EBAS) building is a stand-alone structure, on its own foundation mat, adjacent to the control building (see Section 1.2).

The EBAS building houses the compressed breathing air tank trains and their supporting equipment. The EBAS building is a Seismic Category I structure.

The EBAS building is a reinforced concrete box type shear wall structure consisting of walls and roof slab and is supported by a foundation mat. Concrete framing (steel beams can be used partially) is composite with concrete slab and used to support the roof slab for vertical loads. The EBAS building is a shear wall structure designed to accommodate all seismic loads with its walls and the connected roof. Therefore, frame members such as beams or columns are designed to accommodate deformations of the walls in case of earthquake conditions.

3.8.4.1.5 Radwaste Building

The Radwaste Building (RW) is shown in Section 1.2.

The Radwaste Building (RW) is a reinforced concrete box type structure consisting of walls and slabs and is supported on a foundation mat. The key dimensions of the RW are summarized in Table 3.8-8.

The RW houses the equipment and floor drain tanks, sludge phase separators, resin hold up tanks, detergent drain tanks, a concentrated waste tank, chemical drain collection tank, associated pumps and mobile systems for the radioactive liquid and solid waste treatment systems.

The RW is a Non-Seismic Category (NS) structure. The RW is designed according to the safety classifications defined in Regulatory Guide 1.143 Category RW-IIa.

3.8.4.1.6 Seismic Category I Cable Trays, Cable Tray Supports, Conduits, and Conduit Supports

Electrical cables are carried on continuous horizontal and vertical runs of steel trays or through steel conduits. The tray and conduit locations are based on the requirements of the electrical cable network. Trays or conduits are supported at intervals by supports made of hot or cold rolled steel sections. The supports are attached to walls, floor, and ceilings of structures as required by the arrangement. The type of support and spacing is determined by allowable tray or conduit spans which are governed by rigidity and stress. Bracing is provided where required. The loads, loading combinations, and allowable stresses are in accordance with applicable codes, standards, and regulations consistent with Tables 3.8-6 and 3.8-9.

3.8.4.1.7 Seismic Category I HVAC Ducts and HVAC Duct Supports

HVAC duct locations and elevations are based on the requirements of the HVAC system. HVAC ducts are made of steel sheet metal and are supported at intervals by supports made of hot or cold rolled steel sections. The supports are attached to walls, floor, and ceilings of structures as required by the arrangement. The type of support and spacing is determined by allowable duct spans that are governed by rigidity and stress. Bracing is provided where required. The loads, loading combinations, and allowable stresses are in accordance with applicable codes, standards, and regulations consistent with Tables 3.8-6 and 3.8-9.

3.8.4.2 Applicable Codes, Standards, and Specifications

3.8.4.2.1 Reactor Building

The major portion of the Reactor Building outside Containment structure is not subjected to the abnormal and severe accident conditions associated with a containment. Applicable documents for the RB design are shown in Table 3.8-9, except items 4, 11, 30 and 32.

3.8.4.2.2 Control Building

Applicable documents for the CB design are the same as the RB, which are listed in Table 3.8-9.

3.8.4.2.3 Fuel Building

Applicable documents for the FB design are same as the RB, which are listed in Table 3.8-9.

3.8.4.2.4 Radwaste Building

Applicable codes, standards, specifications and regulations used in the design and construction of RW are items 1, 2, and 32 listed in Table 3.8-9.

3.8.4.2.5 Welding of Pool Liners

Welding activities conform to the AWS Structural Welding Code, Dl.l. All welds are visually inspected before to start any other NDE method. The visual weld acceptance criteria is defined in AWS D1.1. In accordance with approved procedures the welded seams of the liner plate are spot radiographed where accessible, liquid penetrant and vacuum box (ASME Section V) examined after fabrication to ensure that the liner does not leak. Any evidence of leaking is repaired. The acceptance criteria for these examinations conform to the acceptance criteria stated in Subsection NE-5300 of Section III of the ASME Code.

3.8.4.3 Loads and Load Combinations

3.8.4.3.1 Reactor Building

3.8.4.3.1.1 Loads and Notations

This section presents only the loads which are applied to the RB directly. Other loads which are applied to the RCCV only but have effects on RB structures because of common foundation mat, like P_a and T_a, are also considered in the RB design.

Loads and notations are as follows:

D = Dead load of structure plus any other permanent load.

L = Conventional floor or roof live loads, movable equipment loads, and other variable loads such as construction loads. The following live loads are used:

- Concrete floor slabs – 4.8 kPa.
- Concrete roofs – 2.9 kPa.
- Construction live load on floor framing in addition to dead weight of floor – 2.4 kPa.

Live Load L, includes floor area live loads, laydown loads, nuclear fuel and fuel transfer casks, equipment handling loads, trucks, railroad vehicles and similar items. The floor area live load is omitted from areas occupied by equipment whose weight is specifically included in dead load. Live load is not omitted under equipment where access is provided, for instance, an elevated tank on four legs.

The inertial properties include all tributary mass expected to be present in operating conditions at the time of earthquake. This mass includes dead load, stationary equipment, piping and appropriate part of live load established in accordance with the layout and mechanical requirements. In the ESBWR design, 25% of full live load L (designated as L_o), is used in the load combinations that include seismic loads.

However, the live load values used in the governing loading combination for design of local elements such as beams and slabs are the full values.

R_o = Pipe reactions during normal operating or shutdown conditions based on the most critical transient or steady-state condition.

R_a = Pipe reactions under thermal conditions generated by the postulated break and including R_o.

Y_r = Equivalent static load on a structure generated by the reaction on the broken high-energy pipe during the postulated break and including a calculated dynamic factor to account for the dynamic nature of the load.

Y_j = Jet impingement equivalent static load on a structure generated by the postulated break and including a calculated dynamic factor to account for the dynamic nature of the load.

3.8.4.5 Structural Acceptance Criteria

3.8.4.5.1 Reactor Building

The acceptance criteria for the design of the safety-related reinforced concrete structure are included in Table 3.8-15. "U" in Table 3.8-15 is the section strength required to resist design loads based on the strength design method described in Table 3.8-9 item 1 and in SRP 3.8.4 Section II.3.

The acceptance criteria for the design of the safety-related steel structure are included in Table 3.8-16. Allowable elastic working stress, S, is the allowable stress limit specified in Part 1 of ANSI/AISC N-690.

The design criteria preclude excessive deformation of the Reactor Building.

3.8.4.5.2 Control Building

The acceptance criteria for the design of the Control Building are same as the Reactor Building in Section 3.8.4.5.1.

3.8.4.5.3 Fuel Building

Same as the RB in 3.8.4.5.1.

3.8.4.5.4 Radwaste Building

Structural acceptance criteria and materials criteria for the RW is in accordance with Item 32 in Table 3.8-9 for Safety Class RW-IIa.

3.8.5 Foundations

This section describes foundations for all Seismic Category I structures of the ESBWR Standard Plant.

3.8.5.1 Description of the Foundations

The Reactor Building (RB) including the containment and Fuel Building (FB) are built on a common foundation mat as described in Subsection 3.8.4. The foundation of the Control Building (CB) and EBAS are separated from the foundation of the RB and FB and each other.

The foundation of the RB and FB is a rectangular reinforced concrete mat. Its key dimensions are shown in Table 3.8-13. The foundation mat is constructed of cast-in-place conventionally reinforced concrete. It supports the RB, the FB, the containment structure, and other internal structures. The containment structure foundation is defined as within the perimeter or the exterior surface of the containment structure. The containment foundation mat details are discussed in Subsection 3.8.1.1.1.

The Control Building foundation is rectangular reinforced concrete mat. The key dimensions are included in Table 3.8-13.

The foundation for Category 1 structures is contained in the summary stress reports for their respective buildings. The Reactor Building foundation is contained in Appendix 3G Subsection 3G.1, the Control Building foundation is in Appendix 3G Subsection 3G.2, and the

Table 3.8-2

Load Combinations, Load Factors and Acceptance Criteria for the Reinforced Concrete Containment*1,*2,*3

Description	No.	D	L	P_t	P_o	P_a	T_t	T_o	T_a	E'	W	W'	R_o	R_a	Y*4	SRV	LOCA	Acceptance Criteria*6
Service																		
Test	1	1.0	1.0	1.0			1.0											S
Construction	2	1.0	1.0					1.0			1.0							S
Normal	3	1.0	1.0		1.0			1.0					1.0			1.0		S
Factored																		
Severe Environmental	4	1.0	1.3		1.0			1.0			1.5		1.0			1.0		U
Extreme	5	1.0	1.0		1.0			1.0		1.0			1.0			1.0		U
Environmental	6	1.0	1.0		1.0			1.0				1.0	1.0			1.0		U
Abnormal	7	1.0	1.0			1.5			1.0					1.0		1.0	Note*5	U
	8	1.0	1.0			1.0			1.0					1.25		1.0	Note*5	U
	9	1.0	1.0			1.25			1.0					1.0		1.25	Note*5	U
Abnormal/Severe Environmental	10	1.0	1.0			1.25			1.0		1.25			1.0		1.0	Note*5	U
Abnormal/ Extreme Environmental	11	1.0	1.0			1.0			1.0	1.0				1.0	1.0	1.0	Note*5	U

*1: The loads are described in Subsection 3.8.1.3 and acceptance criteria in Subsection 3.8.1.5.

*2: For any load combination, if the effect of any load component (other than D) reduces the combined load, then the load component is deleted from the load combination.

*3: Because Pa, Ta, SRV and LOCA are time-dependent loads, their effects are superimposed accordingly.

*4: Y includes Y_j, Y_m and Y_r.

*5: LOCA loads, CO, CHUG and PS are time-dependant loads for which DLF may be used. The sequence of occurrence is given in Appendix 3B. The load factor for LOCA loads shall be the same as the corresponding pressure load P_a. LOCA loads shall include hydrostatic pressure (with a load factor of 1.0) due to containment flooding.

*6: S = Allowable Stress as in ASME Section III, Div. 2, Subsection CC-3430 for Service Load Combination. U = Allowable Stress as in ASME Section III, Div. 2, Subsection CC-3420 for Factored Load Combination.

Table 3.8-4

Load Combination, Load Factors and Acceptance Criteria for Steel Containment Components of the RCCV (1), (2), (3)

Service Level	No	Load Combination (1)																Acceptance Criteria			
		D	L	P_t	P_o	P_a	T_t	T_o	T_a	E'	W	W'	R_o	R_a	Y (4)	SRV	LOCA (5)	P_m	P_L	P_L+P_b (8)	P_L+P_b+Q
Test Condition	1	1.0	1.0	1.0			1.0											0.75 S_y	1.15Sy	1.15Sy (11)	N/A (10)
Design Condition	2	1.0	1.0			1.0			1.0					1.0				1.0 S_{mc}	1.5 S_{mc}	1.5 S_{mc}	N/A
Level A, B (9)	3	1.0	1.0		1.0			1.0					1.0					1.0 S_{mc}	1.5 S_{mc}	1.5 S_{mc}	3.0 S_{ml}
	4	1.0	1.0		1.0			1.0								1.0					
	5	1.0	1.0			1.0			1.0					1.0							
	6	1.0	1.0			1.0			1.0					1.0		1.0	1.0				
Level C (6)	7	1.0	1.0		1.0			1.0		1.0			1.0					1.2 S_{mc} or* 1.0 S_y	1.8 S_{mc} or* 1.5S_y	1.8 S_{mc} or* 1.5S_y	N/A
	8	1.0	1.0			1.0			1.0	1.0				1.0		1.0	1.0				
	9	1.0	1.0			1.0			1.0			1.0	1.0	1.0	1.0	1.0	1.0				
Level D (7)	10	1.0	1.0			1.0				1.0				1.0	1.0	1.0	1.0	S_f	1.5S_f	1.5S_f	N/A

Notes:

(1) The loads are described in Section 3.8.1.3

(2) For any load combination, if the effects of any load component (other than D) reduces the combined load, then the load component is deleted from the load combination.

(3) P_a ,T_a, SRV and LOCA are time-dependent loads. The sequence of occurrence is given in Appendix 3B.

(4) Y includes Y_j, Y_m and Y_r.

(5) LOCA loads include CO, CHUG and PS. They are time-dependent loads. The sequence of occurrence is given in Appendix 3B. LOCA loads shall include hydrostatic pressure (with a load factor of 1.0) due to containment flooding.

(6) Limits identified by (*) indicate a choice of the larger of the two.

(7) S_f is 85% of the general primary membrane allowable permitted in Appendix F, ASME B&PV Code, Section III. In the application of Appendix F, S_{ml}, if applicable, shall be as specified in Section II, Part D, Subpart 1, Tables 2A and 2B of ASME B&PV Code, which is the same as S_m.

(8) Values shown are for a rectangular section. See NE-3221.3(d) for other than a solid rectangular section.

(9) The allowable stress intensity S_{ml} shall be the S_m listed in Section II, Part D, Subpart 1, Tables 2A and 2B and the allowable stress intensity S_{mc} shall be 1.1 times the S_m listed in Section II, Part D, Subpart 1, Tables 1A and 1B, except S_{mc} shall not exceed 90% of the material's yield strength at temperature shown in Section II, Part D, Subpart 1, Tables Y-1 of the ASME B&PV Code

(10) N/A = No evaluation required

(11) Bending and General Membrane P_m+P_b.

Table 3.8-6

Codes, Standards, Specifications, and Regulations Used in the Design and Construction of Seismic Category I Internal Structures of the Containment

Specification Reference Number	Specification or Standard Designation	Title
1	ACI 301-99	Specifications for Structural Concrete for Builders
2	ACI 307-88	Recommended Practice for Concrete Formwork
3	ACI 305-99	Recommended Practice for Hot Weather Concreting
4	ACI 211.1-91	Recommended Practice for Selecting Proportions for Normal Weight Concrete
5	ACI 315-99	Manual of Standard Practice for Detailing Reinforced Normal Weight Concrete
6	ACI 306-88	Recommended Practice for Cold Weather Concreting
7	ACI 309-96	Recommended Practice for Consolidation of Concrete
8	ACI 308-98	Recommended Practice for Curing Concrete
9	ACI 212-86	Guide for use of Admixtures in Concrete
10	ACI 214-02	Recommended Practice for Evaluation of Compression Test results of Field Concrete
11	ACI 311-88	Recommended Practice for Concrete Inspection
12	ACI 304-00	Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete
13	ACI 349-01	Code Requirements for Nuclear Safety-Related Concrete Structures
14	Not Used	
15	ANSI/AISCN690-1994s2 (2004)	Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities(1)
16	AWS D1.1-04	Structural Welding Code
17	EPRI NP-5380, 1987	Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants (Nuclear Construction Institute Group) Rev. 2, Sep. 1987.
18	ANSI/ASME NQA-1-1989	Quality Assurance Program Requirements for Nuclear Facilities, with Addenda 1a-1989, 1b-1991, and 1c-1992 (Note: more recent revisions exist)
19	Regulatory Guide 1.54	Service Level I, II and III Protective Coatings Applied to Nuclear Power Plants, Rev. 1, July 2000.

Table 3.8-6

Codes, Standards, Specifications, and Regulations Used in the Design and Construction of Seismic Category I Internal Structures of the Containment

Specification Reference Number	Specification or Standard Designation	Title
20	Regulatory Guide 1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants, Rev. 1 and Draft 2.
21	Regulatory Guide 1.136	Materials for Concrete Containments (Article CC-2000 of the Code for Concrete Reactor Vessels and Containments), Jun. 1981
22	Regulatory Guide 1.142	Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments), Nov. 2001
23	Regulatory Guide 1.199	Anchoring Components and Structural Supports in Concrete, November 2003.

Explanation of Abbreviation

ACI American Concrete Institute

AISC American Institute of Steel Construction

AISI American Iron and Steel Institute

ANSI American National Standards Institute

ASME American Society for Mechanical Engineers

AWS American Welding Society

NCIG Nuclear Construction Issues Group

Note:

(1) To comply with NUREG-1503, Appendix G, NRC Position on the use of ANSI/AISC N690 (1984), for impact and impulsive loads, the ductility factors μ in Table Q1.5.8.1 are replaced with the ductility factors in Appendix A to SRP Section 3.5.3.

Table 3.8-7

Load Combination, Load Factors and Acceptance Criteria for Steel Structures Inside the Containment *1, *2

Category	No.	Load Combination D	L	P_o	P_a	T_o	T_a	E'	W	W'	R_o	R_a	Y*4	SRV	LOCA	Acceptance Criteria*5
Normal	1	1.0	1.0	1.0												S
	2	1.0	1.0	1.0		1.0					1.0					$S^{(a)}$
Severe Environmental	3	1.0	1.0	1.0					1.0					1.0		S
	4	1.0	1.0	1.0				1.0						1.0		S
	5	1.0	1.0	1.0		1.0			1.0		1.0			1.0		$S^{(a)}$
	6	1.0	1.0	1.0		1.0		1.0			1.0			1.0		$S^{(a)}$
Extreme Environmental	7	1.0	1.0	1.0		1.0				1.0	1.0			1.0		$1.6S^{(b)(c)}$
	8	1.0	1.0	1.0		1.0		1.0			1.0			1.0		$1.6S^{(b)(c)}$
Abnormal	9	1.0	1.0		1.0		1.0					1.0		1.0	Note*3	$1.6S^{(b)(c)}$
	9a	1.0	1.0		1.0		1.0							1.0	Note*3	$1.6S^{(b)(c)}$
Abnormal/Severe Environmental	10	1.0	1.0		1.0		1.0					1.0	1.0	1.0	Note*3	$1.6S^{(b)(c)}$
Abnormal/Extreme Environmental	11	1.0	1.0		1.0		1.0	1.0				1.0	1.0	1.0	Note*3	$1.7S^{(b)(c)}$

*1 The loads are described in Subsection 3.8.4.3.1.1 and acceptance criteria in Subsection 3.8.4.5.1.

*2 For any load combination, where any load reduces the effects of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occur simultaneously with the other loads. Otherwise, the coefficient for that load shall be taken as zero.

*3 LOCA loads, such us CO, CHUG and PS are time-dependant loads. The sequence of occurrence is given in Appendix 3B. The loads factor for LOCA loads shall be the same as the corresponding Pressure Load P_a. The maximum values of P_a, T_a, R_a, Y including an appropriate Dynamic Load Factor (DLF) shall be used, unless an appropriate time history analysis is performed to justify otherwise. LOCA includes AP loads and effects. LOCA loads shall include hydrostatic pressure (with a load factor of 1.0) due to containment flooding.

*4 Y includes Y_j, Y_m and Y_r.

*5 Allowable elastic working stress (S) is the allowable stress limit specified in Part 1 of ANSI/AISC N-690-1994-s2 (2004).
(a) For primary plus secondary stress, the allowable limits are increased by a factor of 1.5.
(b) Stress limit coefficient in shear shall not exceed 1.4 in members and bolts.
(c) The Stress limit coefficient where axial compression exceeds 20% of normal allowable, shall be 1.5 for load combinations 7, 8, 9, 9a and 10, and be 1.6 for load combination 11.

Table 3.8-9

Codes, Standards, Specifications, and Regulatory Guides Used in the Design and Construction of Seismic Category I Structures

Specification Reference Number	Specification or Standard Designation	Title
1	*ACI 349-01*	Code Requirements for Nuclear Safety-Related Concrete Structures
2	*ANSI/AISC-N690-1994s2(2004)*	Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear *Facilities*(1)
3	*ASME-2004*	Boiler and Pressure Vessel Code Section III, Division 2, Subsection CC
4	ASME-2004	Boiler and Pressure Vessel Code Section III, Subsection NE, Division 1, Class MC (for design of main steam tunnel embedment piping anchorage in the RB only)
5	ANSI/ASME NQA-1-1989	Quality Assurance Program Requirements for Nuclear Facilities, with Addenda 1a-1989, 1b-1991, and 1c-1992 (Note: more recent revisions exist)
6	AWS D1.1 -04	Structural Welding Code - Steel
7	AWS D1.4 -98	Structural Welding Code - Reinforcing Steel
8	AWS D1.6-99	Structural Welding Code for Stainless Steel
9	ASCE 4-98	Seismic Analysis of Safety-Related Nuclear Structures
10	ASCE 7-02	Minimum Design Loads for Buildings and Other Structures
11	AISC360-05	2005 AISC Specification for Structural Steel Building
12	SSPC-PA-1-00	Paint Application Specification No. 1, Shop, Field and Maintenance Painting of Steel
13	SSPC-PA-2-04	Paint Application Specification No. 2, Measurement of Dry Coating Thickness with Magnetic Gages
14	SSPC-SP-1-82	Surface Preparation Specification No. 1, Solvent Cleaning
15	SSPC-SP-5-00	Surface Preparation Specification No. 5, White Metal Blast Cleaning
16	SSPC-SP-6-00	Surface Preparation Specification No. 6, Commercial Blast Cleaning
17	SSPC-SP-10-00	Surface Preparation Specification No. 10, Near-White Blast Cleaning
18	Not Used	
19	Not Used	
20	Regulatory Guide 1.28	Quality Assurance Program Requirements" (Design and Construction), Aug. 1985
21	Regulatory Guide 1.29	Seismic Design Classification, Sep. 1978
22	Regulatory Guide 1.31	Control of Ferrite Content in Stainless Steel Weld Metal, Apr. 1978
23	Regulatory Guide 1.44	Control of the Use of Sensitized Stainless Steel, May 1973
24	Regulatory Guide 1.54	Service Level I, II and III Protective Coatings Applied to Nuclear Power Plants, Rev. 1, July 2000.
25	Regulatory Guide 1.60	Design Response Spectra for Seismic Design of Nuclear Power Plants, Dec. 1973
26	Regulatory Guide 1.61	Damping Values for Seismic Design of Nuclear Power Plants, Oct. 1973
27	Regulatory Guide 1.69	Concrete Radiation-Shields for Nuclear Power Plants, Dec. 1973
28	Regulatory Guide 1.76	Design Basis Tornado for Nuclear Power Plants, Apr. 1974

Table 3.8-9

Codes, Standards, Specifications, and Regulatory Guides Used in the Design and Construction of Seismic Category I Structures

Specification Reference Number	Specification or Standard Designation	Title
29	Regulatory Guide 1.94	Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants, Rev. 1 and draft 2
30	Regulatory Guide 1.136	Materials, Construction and Testing of Concrete Containments (Article CC-2000 of the Code for Concrete Reactor Vessels and Containments), Jun. 1981
31	Regulatory Guide 1.142	Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments), Nov. 2001
32	Regulatory Guide 1.143	Design Guidance for Radioactive Waste Management Systems, Structures and Components Installed in Light Water Cooled Nuclear Power Plants, Nov. 2001
33	Regulatory Guide 1.199	Anchoring Components and Structural Supports in Concrete, November, 2003.
34	(Applicable ASTM Specifications for Materials and Standards)	

Explanation of Abbreviation

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASME	American Society for Mechanical Engineers
AWS	American Welding Society
SSPC	Steel Structures Painting Council

See Subsections 3.8.1.2 and 3.8.3.2 for Applications

Note:

(1) To comply with NUREG-1503, Appendix G, NRC Position on the use of ANSI/AISC N690 (1984), for impact and impulsive loads, the ductility factors μ in Table Q1.5.8.1 are replaced with the ductility factors in Appendix A to SRP Section 3.5.3.

Table 3.8-16

Load Combinations, Load Factors and Acceptance Criteria for the Safety-Related Steel Structures[*1,*2,*3]

Category	Load Combination												Acceptance
	No.	D[*6]	L	Pa	To	Ta	E'	W	Wt	Ro	Ra	Y[*4]	Criteria[*5]
Normal	1	1.0	1.0										S
	2	1.0	1.0		1.0					1.0			S (a)
Severe Environmental	3	1.0	1.0					1.0					S
	4	1.0	1.0		1.0			1.0		1.0			S (a)
Extreme Environmental	5	1.0	1.0		1.0		1.0			1.0			1.6S (b)(c)
	6	1.0	1.0		1.0				1.0	1.0			1.6S (b)(c)
Abnormal	7	1.0	1.0	1.0		1.0					1.0		1.6S (b)(c)
Abnormal/Extreme Environmental	8	1.0	1.0	1.0		1.0	1.0				1.0	1.0	1.7S (b)(c)

*1: The loads are described in Subsection 3.8.4.3.1.1 and acceptance criteria in Subsection 3.8.4.5.1.

*2: For any load combination, where any load reduces the effects of other loads, the corresponding coefficient for that load shall be taken as 0.9 if it can be demonstrated that the load is always present or occur simultaneously with the other loads. Otherwise, the coefficient for that load shall be taken as zero.

*3: Because Pa and Ta are time-dependent loads, their effects are superimposed accordingly.

*4: Y includes Y_j, Y_m and Y_r. The maximum values of Y including an appropriate Dynamic Load Factor (DLF) shall be used, unless an appropriate time history analysis is performed to justify otherwise.

*5: Allowable elastic working stress (S) is the allowable stress limit specified in Part 1 of ANSI/AISC N-690-1994-s2 (2004).

(a) For primary plus secondary stress, the allowable limits are increased by a factor of 1.5.

(b) Stress limit coefficient in shear shall not exceed 1.4 in members and bolts.

(c) Stress limit coefficient where axial compression exceeds 20% of nominal allowable, shall be 1.5 for load combination 5, 6, 7, and be 1.6 for load combination 8.

*6: Dead Load includes settlements.

3G.1.5.2.1.12 Annulus Pressurization (AP) Loads

The annulus pressurization (AP) loads due to FW and RWCU breaks are considered. AP loads contain pressure load and associated jet forces and pipe whip restraint loads.

3G.1.5.2.1.13 Design Seismic Loads

The design seismic loads are obtained by soil – structure interaction analyses, which are described in Appendix 3A. The seismic loads used for design are as follows:

- Figure 3G.1-24: design seismic shears and moments for RB and FB walls
- Figure 3G.1-25: design seismic shears and moments for RCCV
- Figure 3G.1-26: design seismic shears and moments for RPV Pedestal and Vent Wall
- Table 3G.1-9: maximum vertical acceleration

The seismic loads are composed of one vertical and two perpendicular horizontal components. The effects of the three components are combined based on the 100/40/40 method as described in Subsection 3.8.1.3.6.

Seismic lateral soil pressure for wall design is provided in Figure 3G.1-27 using the elastic procedure described in ASCE 4-98 Section 3.5.3.2.

Seismic member forces for each section are obtained directly from the NASTRAN analysis using these seismic input loads.

3G.1.5.2.2 Load Combinations and Acceptance Criteria

Load combinations and acceptance criteria for the various elements of the RB complex are discussed on the following subsections.

3G.1.5.2.2.1 Reinforced Concrete Containment Vessel (RCCV)

Table 3.8-2 gives a detailed list of various Service and Factored load combinations with acceptance criteria per ASME Section III Division 2. Based on previous experience, critical load combinations are selected for the RCCV design. They are mainly combinations including LOCA loads and seismic loads as shown in Table 3G.1-10. The acceptance criteria for the selected combinations are also included in Table 3G.1-10.

3G.1.5.2.2.2 Steel Containment Components

Table 3.8-4 gives a detailed list of various load combinations with acceptance criteria per ASME Section III Division 1, Subsection NE. For the drywell head, the loads of W, W', Ro, Ra, Y, SRV and LOCA are not direct loads and their indirect effects through the supporting RCCV top slab are negligibly small.

3G.1.5.2.2.3 Containment Internal Structures

Table 3.8-7 gives a detailed list of various load combinations with acceptance criteria per ANSI/AISC N690.

3G.1.5.4.1.3 Containment Foundation Mat

Sections 10 and 11 are evaluated for the part of the concrete containment in the foundation mat. The sections are shown in Figure 3G.1-28. The maximum rebar stress is calculated as 271.3 MPa at Section 11 just inside the RPV Pedestal and is shown in Table 3G.1-32. The maximum transverse shear stress of 1.58 MPa is found also at the Section 11 for the load combination CV-11a.

The liner plate maximum strain is found to be 0.0006 at Section 11 as shown in Table 3G.1-35.

3G.1.5.4.1.4 Drywell Head

Figure 3G.1-51 shows the design details. The highest stresses are summarized in Table 3G.1-36. The stresses except PL+Pb+Q at service Level A and B are well within the allowable stress limits. PL+Pb+Q at service Level A and B exceeds allowable, however, it meets all requirements for simplified elastic-plastic analysis stipulated in NE-3228.3 of ASME B & PV Code, Sec.III.

Simplified Elastic-Plastic Analysis

The range of primary plus secondary stress intensity S_n is 794 MPa and the allowable of $3S_{ml}$ is 456 MPa from Table 3G.1-36. S_n exceeds $3S_{ml}$, so simplified elastic-plastic analysis is required. The results of comparison against each requirement of NE-3228.3 are as follows.

(1) NE-3228.3 (a)

The range of primary plus secondary membrane plus bending stress intensity, excluding thermal bending stress is 390 MPa from the result of FEM analysis.

(2) NE-3228.3 (b)

The values of S_a used for entering the design fatigue curve is multiplied by the factor K_e. The values of m and n are decided as 3 and 0.2 respectively from Table NE-3228.3(b)-1 of ASME B & PV Code, Sec. III. Because S_{ml} is 156 MPa from Table 5-2, $3 \cdot m \cdot S_{ml}$ is calculated as 1368 MPa. S_n = 794 MPa is between $3 \cdot S_{ml}$ = 456 MPa and $3 \cdot m \cdot S_{ml}$ = 1368 MPa, so K_e is calculated by the following Formula:

$$K_e = 1.0 + [(1-n)/n \cdot (m-1)] \cdot [(S_n / 3 \cdot S_{ml}) - 1] = 2.49$$

(3) NE-3228.3 (c)

Fatigue evaluation is conducted as follows:

$S_a = K_e \cdot S_n$ = 1978 MPa (287 ksi)

E_1 = 30000 ksi

E_2 = 28100 ksi

Where

E_1: Modulus of elasticity given on the design fatigue curve from Figure I-9.1 of Appendix I of Sec. III.

E_2: Modulus of elasticity at 340°F (170°C) from Table TM-1 of Sec. II, Part D

$S_a' = S_a \cdot (E_1/E_2)$ = 2117 MPa (307 ksi)

S_a for 10 cycles is 3999 MPa (580 ksi) from Table I-9.1 (UTS ≤ 80 ksi) and N for S_a' = 307 ksi is obtained as 38 from Table I-9.1, General Note (b). So the requirement of NE-3228.3 (c) is satisfied.

(4) NE-3228.3 (d)

Because an accident temperature T_a is not a cyclic load, the thermal ratcheting can be neglected.

(5) NE-3228.3 (e)

From Table NE-3228.3(b)-1, the maximum temperature T_{max} is 700°F (370°C) for carbon steel. T_a is 171°C, so it satisfies this requirement.

(6) NE-3228.3 (f)

Specified minimum yield strength S_y and specified minimum tensile strength S_u of SA-516 Gr. 70 are 38 ksi and 70 ksi respectively. The ratio of S_y to S_u is calculated as 0.543. This value is below 0.80. So it satisfies this requirement.

3G.1.5.4.2 Containment Internal Structures

Tables 3G.1-37 through 3G.1-44 show the summary of stress analysis results for containment internal structures.

The type of analyses for various loads considered for the containment internal structures, such as diaphragm floor, vent wall, RPV support bracket (RPVSB), reactor shield wall and GDCS pool are:

1. Dead load
   Static analysis is performed for the dead load to all containment internal structures. Hydrostatic loads of pool water are also applied statically to vent wall and GDCS pool.
2. Pressure load
   Static analysis is performed for the pressure load (Po and Pa) applied to diaphragm floor and vent wall.
3. Thermal load
   Static analysis is performed for the thermal load (To and Ta) to all internal structures. All steel temperature is the same as atmospheric temperature. The temperature of the intermediate node of VW rib plate is the average value of outer and inner plate ones.
4. Seismic load
   Static analysis is performed for the seismic load on diaphragm floor, vent wall, RPV support bracket and reactor shield wall in the integral NASTRAN model, while response spectra analysis is performed for GDCS pool local model.
   In this response spectra analysis, it is assumed that all pool water mass is distributed uniformly on the GDCD pool wall and RCCV wall. This is considered as a conservative assumption, therefore sloshing is not considered in GDCS pool local model. For integral NASTRAN model, however, sloshing load is considered as the static pressure load on DF upper surface and static reaction load from GDCS pool wall. The results from integral NASTRAN model due to these loads are used for the structural integrity evaluation of the structures other than GDCS pool, while the results from GDCS pool local model are used for evaluation of GDCS pool itself.
5. Hydrodynamic load

Table 3G.1-10
Selected Load Combinations for the RCCV

Category	Load Combination											Acceptance Criteria*1
	No.*2	D	L	P_t	P_a	T_a	E'	R_a	SRV	CO	CHUG	
SIT (maximum pressure)	CV-1	1.0	1.0	1.0								S
LOCA (1.5Pa) 6 minutes	CV-7a	1.0	1.0		1.5	1.0		1.0	1.0	1.5		U
LOCA (1.5Pa) 72 hours	CV-7b	1.0	1.0		1.5	1.0		1.0	1.0		1.5	U
LOCA + SSE 6 minutes	CV-11a	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0		U
LOCA + SSE 72 hours	CV-11b	1.0	1.0		1.0	1.0	1.0	1.0	1.0		1.0	U

Note:
*1: S = Allowable Stress as in ASME Section III, Div. 2, Subsection CC-3430 for Service Load Combination.
U = Allowable Stress as in ASME Section III, Div. 2, Subsection CC-3420 for Factored Load Combination.
*2: Based on Table 3.8-2

Table 3G.1-11
Selected Load Combinations for the RB

Category	Load Combination								Acceptance Criteria*1
	No.*2	D	L	P_a*3	T_o	T_a*3	E'	W	
Severe Environmental	RB-4	1.05	1.3		1.3			1.3	U
LOCA (1.5P_a) 6 minutes	RB-8a	1.0	1.0	1.5		1.0			U
LOCA (1.5P_a) 72 hours	RB-8b	1.0	1.0	1.5		1.0			U
LOCA + SSE 6 minutes	RB-9a	1.0	1.0	1.0		1.0	1.0		U
LOCA + SSE 72 hours	RB-9b	1.0	1.0	1.0		1.0	1.0		U

Note:
*1: U = Required section strength based on the strength design method per ACI 349.
*2: Based on Table 3.8-15
*3: P_a and T_a are accident pressure load within the containment and thermal load generated by LOCA, respectively.
P_a and T_a are indirect loads, but their effects are considered in the RB design.

Table 3G.1-35

Containment Liner Plate Strains (Max)

Category	Calculated Strain					Allowable Tension Allowable Compression
	Cylinder	Pedestal	DW Bottom	WW Bottom	Top Slab	
Test	0.0003 -0.0010	0.0004 -0.0006	0.0000 -0.0001	0.0002 -0.0002	0.0002 0.0000	0.002 -0.002
Normal Operation	0.0004 -0.0008	0.0004 -0.0010	0.0001 -0.0003	0.0004 -0.0005	0.0001 -0.0005	0.002 -0.002
Severe Environment	0.0004 -0.0008	0.0004 -0.0010	0.0001 -0.0003	0.0004 -0.0005	0.0001 -0.0005	0.003 -0.005
Extreme Environment	0.0005 -0.0008	0.0004 -0.0010	0.0001 -0.0003	0.0004 -0.0005	0.0002 -0.0005	0.003 -0.005
Abnormal ; LOCA	0.0005 -0.0032	0.0005 -0.0028	0.0001 -0.0004	0.0004 -0.0019	0.0002 -0.0017	0.003 -0.005
Abnormal/Extreme Environment	0.0012 -0.0040	0.0007 -0.0030	0.0002 -0.0006	0.0009 -0.0025	0.0004 -0.0018	0.003 -0.005

3G.3.5 Structural Analysis and Design

3G.3.5.1 Site Design Parameters

The key site design parameters are described in Subsection 3G.1.5.1.

3G.3.5.2 Design Loads, Load Combinations, and Material Properties

3G.3.5.2.1 Design Loads

This section presents only the loads which are applied to the FB directly. Other loads which are applied to the RCCV only but have effects on FB structures because of common foundation mat, like P_a and T_a, are also considered in the FB design.

3G.3.5.2.1.1 Dead Load (D) and Live Load (L and Lo)

The weights of structures are evaluated using the following unit weights.

- reinforced concrete: 23.5 kN/m^3
- steel: 77.0 kN/m^3

Weights of major equipment, miscellaneous structures, piping, and commodities are summarized in Tables 3G.3-1 and 3G.3-2.

Live loads on the FB floor slabs are described in Subsection 3.8.4.3.3.

3G.3.5.2.1.2 Snow Load

The snow load is applied to the roof slab and is taken as shown in Table 3G.1-2. Snow load is reduced to 75% when snow load is combined with seismic loads.

3G.3.5.2.1.3 Lateral Soil Pressure at Rest

The lateral soil pressure at rest is applied to the walls below grade and is based on soil properties given in Table 3G.1-2. Pressures to be applied to the walls are provided in Figure 3G.1-19.

3G.3.5.2.1.4 Wind Load (W)

The wind load is applied to the roof slab and external walls above grade and is based on basic wind speed given in Table 3G.1-2.

3G.3.5.2.1.5 Tornado Load (W_t)

The tornado load is applied to roof slab and external walls above grade and its characteristics are given in Table 3G.1-2. The tornado load, W_t is further defined by the combinations described in Subsection 3G.1.5.2.1.5.

3G.3.5.2.1.6 Thermal Load (T_o)

Thermal loads for the FB are evaluated for the normal operating conditions. Figure 3G.3-1 shows the section location for temperature distributions for various structural elements of the FB, and Table 3G.3-3 shows the magnitude of equivalent linear temperature distribution.

Stress-free temperature is 15.5°C.

Table 3G.3-4

Selected Load Combinations for the FB

Category	Load Combination								Acceptance Criteria*1
	No. *2	D	L	P_a *3	T_o	T_a *3	E'	W	
Severe Environmental	FB-4	1.05	1.3		1.3			1.3	U
LOCA (1.5P_a) 72 hours	FB-8	1.0	1.0	1.5		1.0			U
LOCA + SSE 72 hours	FB-9	1.0	1.0	1.0		1.0	1.0		U

*1: U = Required section strength based on the strength design method per ACI 349

*2: Based on Table 3.8-15.

*3: P_a and T_a are accident pressure load within the containment and thermal load generated by LOCA, respectively.

P_a and T_a are indirect loads, but their effects are considered in the FB design.