ArevaEPRDCPEm Resource

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Sent: Friday, July 30, 2010 4:36 PM
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Subject: DRAFT Response to U.S. EPR Design Certification Application RAI No. 354, FSAR Ch. 3, Questions 3.8.2.11-15
Attachments: RAI 354 5 Response Questions 03.08.02-11 to 15 DRAFT US EPR DC.pdf

Getachew,

To support a final response by August 31, 2010, a draft response is provided for your review. Let me know if the staff has questions or if the response can be sent as final.

Thanks,

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Response to

Request for Additional Information No. 354,
Question 03.08.02-11, Question 03.08.02-12, Question 03.08.02-13,
Question 03.08.02-14, and Question 03.08.02-15

3/16/2010

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.08.02 - Steel Containment
SRP Section: 03.08.05 - Foundations
SRP Section: 03.06.02 - Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping

Application Section: FSAR Ch 3

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

Question 03.08.02-11:

Follow-up to RAI 155, Question Nos. 03.08.02-1, 03.08.02-2, and 03.08.02-5

The containment structure is the most important structure for mitigating the consequences of an accident and protecting the public from radiation exposure. Of all the safety-related structures, the design of the containment structure is the most critical, and requires the highest level of staff review. For the staff to complete its assessment of the containment structure, the design details and design calculations for the equipment hatch, the air locks, the closure for the construction opening, and the high energy piping penetrations need to be completed. In addition, the preliminary design should be developed for the steel components of the fuel transfer tube and representative penetrations (electrical and mechanical) that fall within the jurisdictional boundary of ASME Section III, Subsection NE.

Since the responses to RAIs 03.08.02-1, -2, and -5 did not provide a sufficient description summarizing the design of penetrations, the staff requests that the applicant submit the following information for the equipment hatch, the air locks, the closure for the construction opening, and the high energy piping penetrations that fall within the jurisdictional boundary of ASME Section III, Subsection NE:

(1) material(s) of construction and detailed geometry;

(2) description of the design-basis analyses conducted;

(3) summary of the analysis results; and

(4) comparison of results to ASME Section III, Subsection NE acceptance criteria.

This information should also be included in FSAR Section 3.8.2. The applicable detailed calculations should be available for staff review at a future audit.

Response to Question 03.08.02-11:

The containment penetrations for the personnel and emergency airlocks, closure for the construction opening, equipment hatch, main steam and feedwater piping, and the fuel transfer tube have been evaluated to verify integrity of the containment pressure boundary.

SA-516 Grade 70 material is used for the major components (shell and containment liner sleeve penetration assemblies) that interface with containment. Dimensional information used in the evaluations is based on U.S. EPR FSAR Tier 2, Figures 3.8-25 through 3.8-27, Figure 3.8-31, and Figures 3.8-120 and 3.8-123, and information supported by AREVA NP design specifications.

Analysis methods use finite element modeling techniques to represent the penetration assemblies and interfaces at the containment boundary. Figure 03.08.02-11-1 is used to evaluate the personnel and emergency airlocks. Loads and load combinations for design, testing, and Service Levels A, B, C, and D are evaluated. Load cases consider conditions of operations, e.g., inner hatch closed or open, loadings associated with ancillary equipment of the penetration such as hatch doors, and built-up floors.

The stresses resulting from the evaluations are tabulated and compared to the stress limits determined in accordance with ASME Boiler and Pressure Vessel Code 2004, Section III, Division 1, Subsection NE (Class MC Components) for each loading condition and verified for compliance.

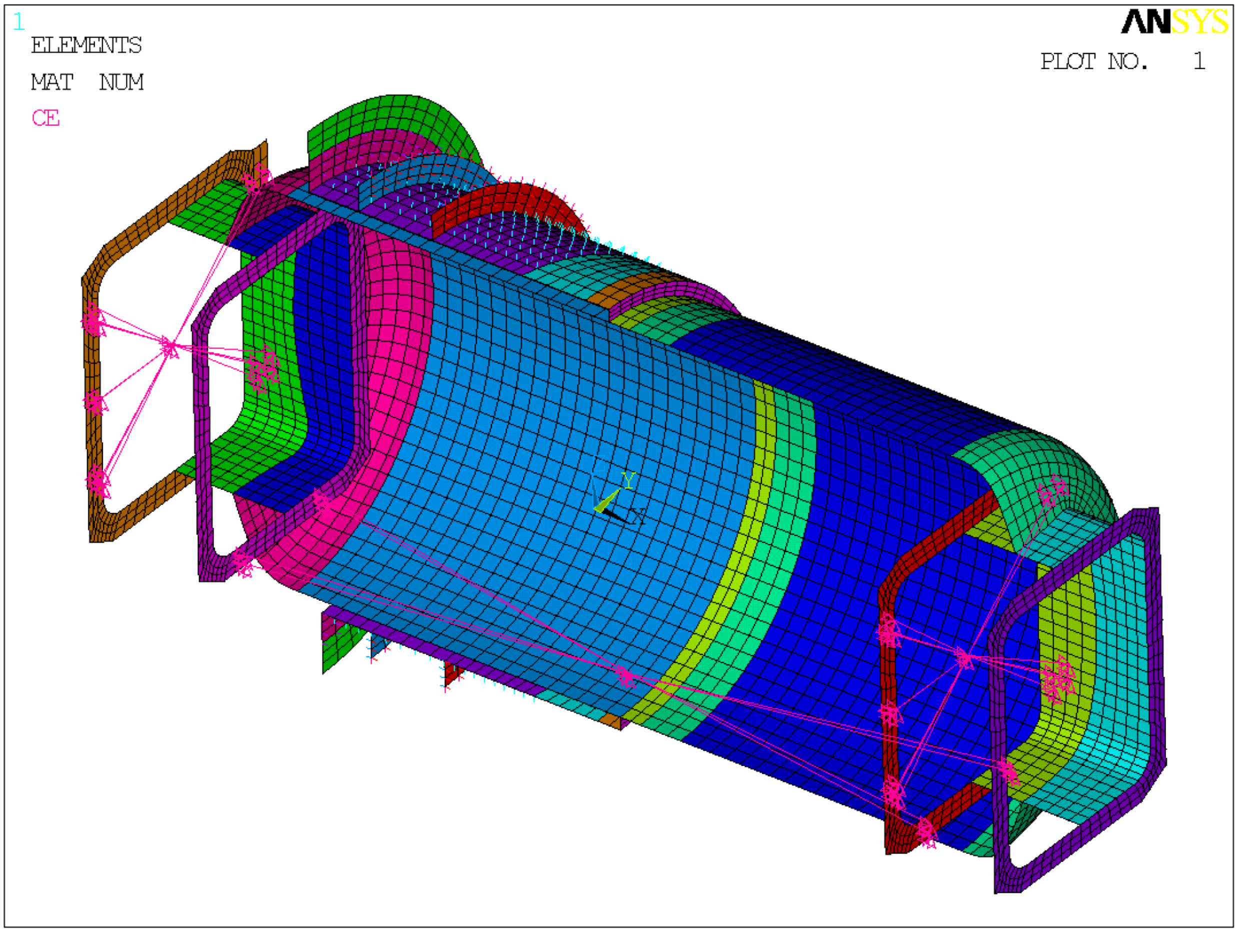
The detailed calculations supporting the analyses described in this response are available for NRC inspection.

U.S. EPR FSAR Tier 2, Sections 3.8.2.1.1, 3.8.2.1.2, 3.8.2.4, 3.8.2.6; Figures 3.8-25, 3.8-26, 3.8-27, 3.8-31, and Table 6.1-1 will be revised and Figures 3.8-120 and 3.8-123 added to provide additional information related to the containment penetrations.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.8.2.1.1, 3.8.2.1.2, 3.8.2.4, 3.8.2.6; Figures 3.8-25, 3.8-26, 3.8-27, 3.8-31and Table 6.1-1 will be revised and Figures 3.8-120 and 3.8-123 as described in the above response and indicated on the enclosed markup.

Figure 03.08.02-11-1—ANSYS Model (Personnel and Emergency Airlocks)



Question 03.08.02-12:

Follow-up to RAI 155, Question No. 03.08.02-3

The staff determined that the information provided in the applicant's RAI response for the fuel transfer tube is insufficient to complete a safety evaluation. The following additional information is needed to resolve this RAI:

1. Provide sufficient details for all components of the penetration closure within the jurisdictional boundary of the RCB. These details should include sufficient information to determine adequacy of the load path (e.g. key structural members in the load path, anchorage of key components to RCB, etc.).
2. FSAR Tier 2, Section 9.1.4.2.2 states: "The fuel transfer tube is provided with expansion joints on the RB and FB side to accommodate the differential movement and provide leak tight sealing." The staff cannot assess the adequacy of the design based on this statement alone. Provide sufficient description and details of the expansion joints to facilitate the staff's review of the design adequacy to accomplish the intended functions which were stated to be differential movement and leak-tightness. At a minimum, this should include material, geometry, and a summary of analyses performed, analysis results, and comparison to acceptance criteria.

This information should also be included in FSAR Section 3.8.2. The applicable detailed calculations should be available for staff review at a future audit.

Response to Question 03.08.02-12:

1. The Reactor Containment Building (RCB) is a concrete containment structure with a metallic liner and is designed to the requirements of ASME Code, Section III, Division 2. Where the fuel transfer tube penetration sleeve is backed by concrete, the penetration is designed to ASME Code, Section III, Division 2. The jurisdictional boundary changes where the penetration sleeve is not backed by concrete. The portion of the sleeve not backed by concrete and appurtenances attached to the sleeve are designed to the requirements of ASME Boiler and Pressure Vessel Code 2004, Section III, Division 1, Subsection NE (Class MC Components). The containment boundary consists of the penetration sleeve, liner plate, ring plate, bride, fuel transfer tube, and blind flange.

   The fuel transfer tube penetration sleeve is nominally 3/4 inch thick, 36 inches in diameter, and embedded in the RCB wall. Penetration sleeve anchors verify distribution of applied forces and moments between the concrete and the sleeve. The two sleeve anchors are nominally 3/4 inch thick plate, eight inches in height, and continuously welded around the circumference of the sleeve. The portion of the penetration sleeve backed by concrete and the embedded anchors are designed to ASME Code, Section III, Division 2, Section CC-3740.

   The fuel transfer tube penetration sleeve is welded to the containment liner plate by means of a transitional ring plate continuously welded around the circumference of the sleeve. The ring plate is nominally 12 inches in height, 7/8 inch thick tapering to 1/4 inch at the liner plate connection, which is a complete penetration weld. The penetration sleeve is connected to the stainless steel fuel transfer tube through a fabricated "bride" fitting. The bride fitting is welded to fuel transfer tube.

U.S. EPR FSAR Tier 2, Figure 3.8-31 will be revised to depict the location of the penetration sleeve anchors and blind flange. U.S. EPR FSAR Tier 2, Section 3.8.2.1.4 will be revised to include the diameter of the fuel transfer tube penetration sleeve.

2. The fuel transfer tube assembly is designed to the requirements of ASME Boiler and Pressure Vessel Code 2004, Section III, Division 1, Subsection NE (Class MC Components) from the jurisdictional boundary with Division 2 at the RCB liner to a blind flange located within the transfer tube compartment inside the RCB. The expansion joints (bellows) at the fuel transfer tube compartment inside the RCB, the Reactor Shield Building wall, and the Fuel Building transfer pit wall are not part of the containment pressure boundary.

   No detailed calculations were necessary to support this response.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.8.2.1.4 and Figure 3.8-31 will be revised as described in the above response and indicated on the enclosed markup.

Question 03.08.02-13:

Follow-up to RAI 155, Question No. 03.08.02-4

The staff requests that the applicant submit the following information related to buckling analysis of the equipment hatch, the air locks, the closure for the construction opening, and the high energy piping penetrations:

(1) a description of the design-basis analyses conducted;

(2) a summary of the analysis results; and

(3) a comparison of results to ASME Section III, Subsection NE-3130 and/or Code Case N-284 acceptance criteria.

This information should also be included in FSAR Section 3.8.2. The applicable detailed calculations should be available for staff review at a future audit.

Response to Question 03.08.02-13:

Analyses have been performed for the equipment hatch, the airlocks, construction opening, and high energy piping penetrations. The analyses include evaluations for the effects of buckling on the penetrations. The evaluations confirm acceptable performance and that the penetrations satisfy the Code Case N-284 buckling acceptance criteria.

The method of analysis includes a linear buckling analysis using the Eigen value method to predict the theoretical buckling load, non-linear buckling analysis considering large deflection and plasticity of the material to obtain a more accurate buckling pressure, and hand calculations per ASME Section III, Subsection NE-3133 to obtain a maximum allowable pressure. The calculated pressure is compared to 1/3 of the buckling pressure and the smaller value is conservatively used as the allowable buckling pressure.

Simple geometries (e.g., piping penetrations) are qualified in accordance with NE-3133 or Code Case N-284-1. The calculated stresses are compared to the allowable buckling limits for the design condition (e.g., design, testing, Service Level A, B, C, D) as defined in NE-3222-1, 3222-2 and 3226(e). More complex geometries (e.g., airlocks) are analyzed using rigorous finite element buckling analyses per NE-3222.1(a)(1).

The detailed calculations supporting the analyses described in this response are available for NRC inspection.

U.S. EPR FSAR Tier 2, Section 3.8.2.4 will be revised to provide additional information related to the containment penetration buckling analysis.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.8.2.4 will be revised will be revised as described in the above response and indicated on the enclosed markup.

Question 03.08.02-14:

Follow-up to RAI 155, Question No. 03.08.02-6

The staff reviewed the electrical penetration figures provided with the initial RAI response. They are acceptable to describe typical electrical penetrations. However, there is no information on the design of the sleeves that support the electrical penetrations. The staff requests that the applicant provide the following additional information:

1. range of penetration diameters,
2. sleeve material and thickness, and
3. method of analysis used to demonstrate adequacy of the sleeve and its anchorage into concrete.

The staff also requests that the applicant confirm that the applicable procurement criteria will identify the required pressure resisting capability of the electric penetrations, and will include a requirement that the vendor demonstrate design adequacy in accordance with SRP Section 3.10. If not, then explain what alternative method of qualification will be implemented.

Response to Question 03.08.02-14:

1. Electrical penetration sleeve diameters range from 18 to 24 inches (nominally).
2. The Reactor Containment Building (RCB) is a concrete containment structure with a metallic liner and is designed to the requirements of ASME Code, Section III, Division 2. Where the electrical penetration sleeve is backed by concrete, the penetration is designed to ASME Code, Section III, Division 2 standards. The jurisdictional boundary changes where the penetration sleeve is not backed by concrete. The sleeve and appurtenances not backed by concrete are designed to the requirements of ASME Boiler and Pressure Vessel Code 2004, Section III, Division 1, Subsection NE (Class MC Components). Penetration sleeve materials are per ASME Code, Section III, Division 2, and as summarized in U.S. EPR FSAR Tier 2, Table 6.1-1.

   The electrical penetration sleeves are nominally 5/8 inch to 3/4 inch thick and embedded in the RCB wall. Penetration sleeve anchors are included to verify distribution of applied forces and moments between the concrete and the sleeve. The two sleeve anchors are nominally 3/4 inch thick, six inches in height, and continuously welded around the circumference of the sleeve. The penetration sleeve and anchors are designed to ASME Code, Section III, Division 2, Section CC-3740 standards. The electrical penetration sleeves are welded to the containment liner plate by means of a transitional ring plate continuously welded around the circumference of the sleeve. The ring plate is nominally 3/4 inch thick tapering to 1/4 inch at the liner plate connection, which is a complete penetration weld. U.S. EPR FSAR Tier 2, Section 3.8.2.1.3 will be updated and Figures 3.8-121 and 3.8-122 will be added to depict the location of the penetration sleeve anchors.
3. The electrical penetrations are designed to the requirements of ASME Boiler and Pressure Vessel Code 2004, Section III, Division 1, Subsection NE (Class MC Components) from the jurisdictional boundary with Division 2 at the RCB liner to a connection point provided by the vendor supplied electrical equipment. Specific fabrication details such as material and

geometry are not available at this time since these are procured items that fall under the detailed design scope.

U.S. EPR FSAR Tier 2, Section 3.10 and Section 8.3.1.2.7 identify design, construction and testing requirements for electrical penetrations.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 3.8.2.1.3 will be revised and Figures 3.8-121 and 3.8-122 will be added as described in the response and indicated on the enclosed markup.

Question 03.08.02-15:

Follow-up to RAI 155, Question No. 03.08.02-8

While the information provided in the initial RAI response is helpful to understand how AREVA plans to accommodate differential movement between the RCB and the RSB, the staff needs additional description and detail before it can complete its review of this design aspect. The staff's primary concern is the integrity of the containment pressure boundary. Therefore, the staff requests that AREVA describe the loads that are imposed on the containment penetrations due to differential movement between the RCB and the RSB, and also describe how these loads are considered in the design of the containment penetrations.

This information should also be included in FSAR Section 3.8.2. The applicable detailed calculations should be available for staff review at a future audit.

Response to Question 03.08.02-15:

The construction opening maintains the containment pressure boundary within the Reactor Containment Building (RCB). There are no expansion joints for the construction opening. The construction opening penetrates through the RCB wall, but is not attached to the Reactor Shield Building (RSB) wall, as shown in U.S. EPR FSAR Tier 2, Figure 3.8-123. There are no loads imposed on the construction opening due to differential movement between the RCB and the RSB.

The personnel airlock, emergency airlock, and equipment hatch contain flexible expansion joints which connect the RCB penetration sleeves to the RSB penetration sleeve to allow differential movement and minimize load transfer between the RCB and RSB. U.S. EPR FSAR Tier 2, Sections 3.8.2.1.1 and 3.8.2.4.1 will be updated to describe the expansion joints. The bellows provide a boundary for annulus ventilation. The stiffness is expected to have no effect on the qualification of the penetration sleeves. The equipment hatch is shown in U.S. EPR FSAR Tier 2, Figure 3.8-25, and the personnel airlock and emergency airlock are shown in U.S. EPR FSAR Tier 2, Figure 3.8-26.

The main steam line and feedwater penetration sleeves contain expansion bellows to allow differential movement and minimize load transfer between the RCB and RSB. The bellows attached to the RSB are not part of the containment pressure boundary. U.S. EPR FSAR Tier 2, Section 3.8.2.1.2 will be updated to describe the expansion bellows. The feedwater and main steam line penetration sleeves are shown in U.S. EPR FSAR Tier 2, Figure 3.8-27 and Figure 3.8-120, respectively.

The fuel transfer tube expansion bellows shown in U.S. EPR FSAR Tier 2, Figure 3.8-31 allow for differential movement, but are not part of the containment pressure boundary. The stiffness of the expansion bellows for the fuel transfer tube is modeled in a sub-model as springs connected to fixed nodes.

The detailed calculations supporting the analyses described above are available for NRC inspection.

FSAR Impact:

U.S. EPR FSAR Tier 2, Sections 3.8.2.1.1, 3.8.2.1.2 and 3.8.2.4.1 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

Thirty-six RCB locations will be monitored for radial displacement, 6 for vertical displacement and 13 on the dome for tri-directional displacement. Table 3.8-7—ISI Schedule for the U.S. EPR.

The RCB is fully enclosed by the RSB; therefore, the potential for corrosion of the tendon system is significantly reduced.

Section 6.2.6 contains a description of the associated leak-rate test procedure, Containment Integrated Leakage Rate Test (CILRT). Containment pressure testing will occur in conjunction with the CILRT.

Sufficient physical access is provided in the annulus between the RCB and the RSB to perform inservice inspections on the outside of the containment. Space is available inside of the RCB to perform inservice inspections of the liner plate. Gaps are provided between the liner and RB internal structures concrete structural elements, which provide space necessary to inspect the liner at wall and floor locations inside containment. Inservice inspection of the embedded portion of the containment liner and the surface of the concrete containment structure covered by the liner are exempted in accordance with Section III of the ASME ~~BPV~~ Code for Class CC components.

3.8.2 Steel Containment

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

3.8.2.1 Description of the Containment

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

3.8.2.1.1 Equipment Hatch, Airlocks, and Construction Opening

03.08.02-15

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

03.08.02-15

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

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

The personnel airlock at [azimuth 0°] opens into a [stair tower between SBs 2 and 3,] which is a Seismic Category I structure. The emergency airlock opens into the [southwest stair tower of the FB at azimuth 230°], which is a Seismic Category I structure. Therefore, both airlocks are protected from external environmental hazards (e.g., high wind, tornado wind and missiles, and other site proximity hazards, including aircraft hazards and blasts). The personnel airlock and the emergency airlock have inside diameters of approximately 10 feet, 2 inches.

The construction opening is located at [azimuth 230° (elevation +8 feet, 6 inches)] and opens to the heavy load operating floor level from [the stair tower that connects the FB and SB 1.] This passage serves as personnel and material access into the RB during construction. The construction opening has an outside diameter of approximately 9 feet, 6 inches. Upon completion of construction work, the cavity in the RCB is permanently sealed with a metal closure cap welded ~~in place metal closure cap~~to an embedded sleeve. The construction opening is shown in Figure 3.8-123.

03.08.02-11

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

3.8.2.1.2 Piping Penetration Sleeves

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

- High-energy penetrations:

  This type of penetration is used for high-energy piping. Examples of high-energy penetrations are those provided for the safety injection or chemical and volume control lines. High-energy piping penetrations consist of the following major steel items:

  - Process pipe – Process pipes are welded or seamless and are made of carbon or stainless steel. The pipes are welded to a connecting part centrally located in the annulus between the inner containment wall and the outer shield wall. The connecting part is welded to an embedded sleeve in the inner containment wall. This acts as an anchor for the penetration. The guard pipe is also connected to the connecting part. The process pipes conform to the requirements of ASME BPV Code Section III, Subsection NC and meet the requirements of the piping system they serve as described in Section 3.6.

  - Connecting part – Connecting parts are made from forged carbon or stainless steel and conform to ASME BPV Code Section III, Division 1, Subsection NC. The connecting process pipes and connecting part are each designed and analyzed to be capable of carrying loads in the event of failure of the process pipes as described in Sections 3.6 and 3.9.

  - Pipe sleeve – Pipe sleeves are made from carbon or stainless steel and consist of the portion of the penetration that projects into the RCB and supports the connecting part. Pipe sleeves conform to ASME BPV Code Section III, Division 1, Subsection NE (GDC 1).

03.08.02-15

- Main steam and feedwater penetrations:

  These penetrations are a special adaptation of the high-energy penetrations. The design is the same as the high-energy penetration except it has a guard pipe that fits tightly over the process pipe in the inner containment sleeve that is designed to dissipate heat and prevent the concrete from overheating. The protection pipes are connected to the RSB penetration sleeve by expansion bellows, as shown in Figures 3.8-120 and 3.8-27. The bellows allow differential movement and minimizes load transfer between the RCB and RSB.

- Standard piping penetration:

This penetration type is used for moderate or low energy piping lines. The basic configuration consists of an inline flued head component attached to the inner containment embedded pipe sleeve. There is no guard pipe, but ~~isolation of the annulus is provided by~~ an expansion joint attached to the pipe and ~~the outer shield wall~~ sleeve allows differential movement and minimizes load transfer between the RCB and RSB. These penetrations consist of:

- Process pipe and flued head – Process pipes are welded or seamless and are made of carbon or stainless steel. The pipes are welded to the flued head. Flued heads are made from forged carbon or stainless steel. Process pipes and flued heads conform to Subsection NC of the ASME ~~BPV~~ Code, Section III, Division 1, and meet the requirements of the piping system they serve as described in Section 3.6.

- Pipe Sleeve – Pipe sleeves are made from carbon or stainless steel and consist of the portion of the penetration that projects into the RCB and supports the flued head. Pipe sleeves conform to ASME ~~BPV~~ Code Section III, Division 1, Subsection NE (GDC 16).

● Spare penetrations:

Spare penetrations are reserved for future use. Spare penetrations consist of the following major items:

- Solid closure plate or pipe cap – Closure plates and pipe caps are made from carbon or stainless-steel and conform to the requirements of Subsection NC of the ASME ~~BPV~~ Code, Section III, Division 1, Subsection NC.

- Pipe sleeve – Pipe sleeves are made from carbon or stainless-steel and consist of the portion of the penetration that projects into the RCB. Pipe sleeves conform to ASME ~~BPV~~ Code Section III, Division 1, Subsection NE (GDC 16).

03.08.02-11

Typical details of piping penetrations are illustrated in Figure 3.8-27—Containment Penetrations for ~~Main Steam and~~ Feedwater Pipes, Figure 3.8-28—Containment Penetrations for High Energy Pipes, Figure 3.8-29—Containment Standard Piping Penetrations – Single Pipe, ~~and~~ Figure 3.8-30—Containment Standard Piping Penetrations – Multiple Pipes, and Figure 3.8-120—Containment Penetration for Main Steam Pipe.

3.8.2.1.3 Electrical Penetration Sleeves

03.08.02-14

Sleeves for electrical penetrations consist of the portion of penetrations that projects into the RCB and supports the electrical assembly. Sleeves conform to ASME ~~BPV~~ Code Section III, Division 1, Subsection NE (GDC 16).

Typical details of electric penetrations are illustrated in Figure 3.8-121—Low Voltage Penetration Sleeve and in Figure 3.8-122—Medium Voltage Penetration Sleeve.

3.8.2.1.4 Fuel Transfer Tube Penetration Sleeve

03.08.02-12

The fuel transfer tube penetration is provided to transfer fuel between the refueling canal and the spent fuel pool during the refueling operations of the reactor. The penetration consists of an approximately 20 inch diameter stainless steel pipe installed inside a larger 36 inch diameter penetration sleeve that is anchored to the concrete RCB. The steelpenetration sleeve conforms to Subsection NE of the ASME BPV Code, Section III, Division 1 (GDC 16). The inner pipe acts as the transfer tube. The sleeve is designed to provide integrity of the RCB, allow for differential movement between the RB internal structures and the FB and the RCB, and prevent leakage through the fuel transfer tube in the event of an accident. Bellows and water-tight sealsExpansion joints are provided around the fuel transfer tube where it passes through the RB internal structures refueling canal concrete and the RSB and FB concrete to allow for differential movement between the structures and to maintain leak-tight boundaries for the refueling pools and the annulus ventilation system. Figure 3.8-31—Fuel Transfer Tube Penetration (Conceptual View) illustrates the fuel transfer tube penetration.

3.8.2.2 Applicable Codes, Standards, and Specifications

The following codes, standards, specifications, design criteria, regulations, and regulatory guides are used in the design, fabrication, construction, testing, and inservice inspection of steel portions of the RCB that are intended to resist pressure, but are not backed by structural concrete (GDC 1, GDC 2, GDC 4, GDC 16 and GDC 50).

The boundaries between the RCB and the steel pressure boundary component consist of those defined in ASME Code, Section III, Division I, Paragraph NE-1132. Section 3.8.1.2 describes codes, standards, and specifications applicable to the containment steel liner.

3.8.2.2.1 Codes

- ANSI/AISC N690-1994 (R2004), Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities, including Supplement 2.
- ANSI/AWS D1.1-2000/D1.1M-2006, Structural Welding Code – Steel.
- ANSI/AWS D1.6-1999, Structural Welding Code – Stainless Steel.
- ASME BPV Code – 2004 Edition:
  - Section II – Material Specifications.
  - Section III, Division 1 – Nuclear Power Plant Components.

Level C Service Limits

These service limit load combinations include the loads subject to Level A service limits, plus the additional loads resulting from natural phenomena for which safe shutdown of the plant is required (GDC 2, GDC 4, GDC 50).

$$P^* = D + L + T_o + R_o + P_v + E'$$

$$P^* = D + L + T_a + R_a + P_a + E'$$

$$P^* = D + P_{g1} + P_{g2.}$$

In the last load combination, $P_{g1} + P_{g2}$ should not be less than 45 psig and evaluation of instability is not required as specified by the code.

Level D Service Limits

These service limit load combinations include other applicable service limits and dynamic loads for which containment function is required (GDC 2, GDC 4, and GDC 50).

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$$P^* = D + L + T_a + R_a + P_a + R_{rr} + R_{rj} + R_{rm} + E'$$

$$P^* = D + L + F_a + E.$$

3.8.2.4 Design and Analysis Procedures

The steel items described in Section 3.8.2.1 are designed and analyzed in accordance with Article NE-3000 of Subsection NE of the ASME Code, Section III, Division 1, and as augmented by the applicable provisions of RG 1.57 (GDC 1 and GDC 16).

Containment penetrations, or portions thereof, within the jurisdictional boundaries defined by ASME Code, Section III, Division 1, Subsection NE do not exceed the stress intensity limits defined by Articles NE-3221.1, NE-3221.2, NE-3221.3, and NE- 3221.4 of the ASME BPV Code. Code class shell components are evaluated for buckling under earthquake, thermal, and pressure loads. The method of analysis involves performing a linear buckling analysis using the Eigen value method to predict the theoretical buckling load, a non-linear buckling analysis considering large deflections and plasticity of the material to obtain a buckling pressure, and hand calculations per ASME Section III, Subsection NE-3133 to obtain a maximum allowable pressure. The calculated pressure is compared to 1/3 of the buckling pressure, and the smaller value is conservatively used as the allowable buckling pressure.

Simple geometries, e.g., piping penetrations, are qualified in accordance with NE-3133 or ASME Code Case N-284-1. The calculated stresses are compared to the allowable buckling limits for the particular design condition, e.g., design, testing, and Service

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Level A, B, C, D. More complex geometries (e.g., air locks) are analyzed using rigorous finite element buckling analyses.

Evaluation of the containment penetrations use 3-D finite element modeling techniques (ANSYS) using loads and load combinations discussed in Sections 3.8.2.3.1 and 3.8.2.3.2, respectively.

Code class MC components are screened for cyclic service analysis according to the criteria in Article NE-3221.5 of the ASME Code.

Refer to Section 3.5.3 for a description of requirements for missile barrier design and ductility requirements applicable to the design of steel portions of the RCB.

The following sections provide individual descriptions of the design and analysis procedures performed to verify the structural integrity of the steel items. Section 3.8.1 addresses the design and analysis procedures used to qualify the RCB concrete structure for openings provided through the containment pressure boundary for these items. Containment ultimate capacity analysis results are described in Section 3.8.1.4.11, which includes evaluation of major containment steel penetrations.~~The steel items described in Section 3.8.2.1 will be designed and analyzed in accordance with Article NE-3000 of Subsection NE of the ASME BPV Code, Section III, Division 1, and as augmented by the applicable provisions of RG 1.57 (GDC 1 and GDC 16).~~

~~Containment penetrations, or portions thereof, within the jurisdictional boundaries defined by ASME BPV Code, Section III, Division 1, Subsection NE do not exceed the stress intensity limits defined by Articles NE-3221.1, NE-3221.2, NE-3221.3, and NE-3221.4 of the ASME BPV Code. Code class shell components are evaluated for buckling under earthquake, thermal, and pressure loads. Buckling of shells with more complex geometries and loading conditions than those covered by Article NE-3133 of the Code is considered in accordance with ASME BPV Code Case N-284-1 and additional guidance in RG 1.193. An acceptable approach to evaluating buckling of shells is to perform a non-linear analysis. Code class MC components are screened for cyclic service analysis according to the criteria given in Article NE-3221.5 of the ASME BPV Code.~~

~~Refer to Section 3.5.3 for a description of requirements for missile barrier design and ductility requirements applicable to the design of steel portions of the RCB.~~

~~The following sections provide individual descriptions of the design and analysis procedures performed to verify the structural integrity of the steel items. Section 3.8.1 addresses the design and analysis procedures used to qualify the RCB concrete structure for openings provided through the containment pressure boundary for these items. Containment ultimate capacity analysis results are described in Section 3.8.1.4.11, which includes evaluation of major containment steel penetrations.~~

3.8.2.4.1 Equipment Hatch, Airlocks, and Construction Opening

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The equipment hatch described in Section 3.8.2.1.1 is supported entirely by the concrete shell of the RCB. The barrelsleeve of the equipment hatch is embedded in the concrete containment shell and welded at the periphery to the liner plate. Expansion joints, located in the annulus, allow for differential movement and minimize load transfer between the RCB and RSB walls. The expansion joints maintain the pressure boundary for the annulus ventilation system. The liner plate is thickened in the vicinity of the equipment hatch penetration. The equipment hatch cover is dished and stiffened by a reinforcing ring where it interfaces with the barrelsleeve of the equipment hatch.

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The two airlocks described in Section 3.8.2.1.1 are supported by attachment to penetration sleeves embedded in the concrete shell of the RCB and by supports attached to the RSB wall. These supportsExpansion joints provide for differential movements of theand minimize load transfer between containment and shield walls. The doors for both ends of the airlocks are flat, and the bulkhead ends of the components are dished.

The construction opening closure cap described in Section 3.8.2.1.1 is attached to and supported by a sleeve embedded in the concrete shell of the RCB. The closure cap is a dish shaped metal structure welded to the embedded sleeve flange.

The equipment hatch, airlocks, and construction opening closure cap and sleeve will be evaluated for the combinations of loads described in Section 3.8.2.3.2. Analyses and limits for the resulting stress intensities in the equipment hatch, airlocks, and the construction opening closure cap and sleeve will be designed in accordance with Articles NE-3130, NE-3200, NE-3325, and NE-3326 of Section III, Division 1 of the ASME BPV Code.

3.8.2.4.2 Piping, Electrical, and Fuel Transfer Tube Penetration Sleeves

The penetration sleeves are welded to the containment liner plate and are anchored to the RCB concrete shell. Penetration sleeves are subjected to various combinations of mechanical, thermal, and seismic loadings and will be evaluated for the combination of loads described in Section 3.8.2.3.2.

If the penetration sleeves are subjected to cyclic service, the associated peak stress intensities will be evaluated. The required analysis and associated stress intensity limits will be in accordance with Articles NE-3130 and NE-3200 of Section III, Division 1 of the ASME BPV Code.

3.8.2.4.3 Design Report

Design information and criteria for Seismic Category I structures are provided in Sections 2.0, 2.4, 2.5, 3.3, 3.5, 3.7, 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5. Design results are presented in Appendix 3E for Seismic Category I structure critical sections. A cross-reference between U.S. EPR FSAR sections and information required by SRP Section 3.8.4, Appendix 3C is provided in Table 3.8-17.

3.8.2.5 Structural Acceptance Criteria

Structural acceptance criteria for steel containment items described in Section 3.8.2.1 are in accordance with Subsection NC and NE of the ASME BPV Code, Section III, Division 1, including allowable stress limits, strain limits, deformation limits, and factors of safety. These are augmented by the requirements of RG 1.57 (GDC 1, GDC 2, GDC 4, GDC 16, and GDC 50). Containment steel items not backed by concrete that are intended to resist pressure will be designed to meet the acceptance criteria for the load combinations listed in Section 3.8.2.3.2.

Steel items that are an integral part of the RCB pressure boundary will be designed to meet minimum leakage rate requirements. The leakage rate must not exceed the acceptable value indicated in the applicable technical specification.

The design and analysis methods, as well as the type of construction materials, are chosen to allow assessment of the capability of steel items to function properly throughout the plant life.

A SIT is performed as described in Section 3.8.2.7. Surveillance testing provides assurance of the continuing ability of each item to meet its design functions. Surveillance requirements are addressed in Section 3.8.2.7.

Items that form part of the containment pressure boundary are stamped in accordance with the applicable section of the ASME BPV Code used for their design or fabrication.

3.8.2.6 Materials, Quality Control, and Special Construction Techniques

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Steel items that are not backed by concrete that are part of the containment pressure boundary are fabricated from materials that meet the requirements specified in Article NE-2000 of Section III, Division 1 of the ASME BPV Code, except as modified by applicable and acceptable ASME BPV Code cases (GDC 1). SA-516 Grade 70 material is used for major steel components of the penetration assemblies. The materials are defined in Table 6.1-1.

Quality control for containment steel items conforms to Articles NE-2000, NE-4000, and NE-5000 of Section III, Division 1 of the ASME BPV Code (GDC 1).

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Figure 3.8-25—Equipment Hatch General Assembly

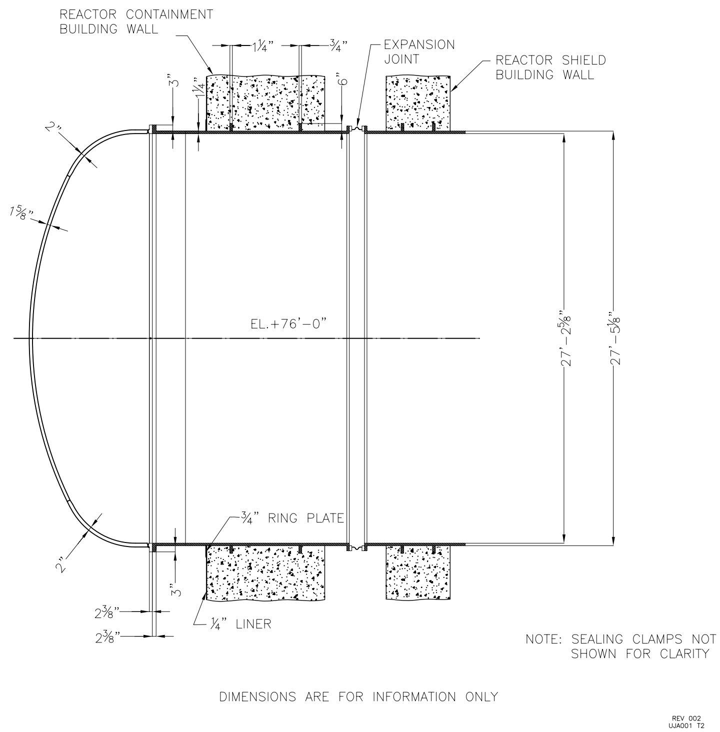

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Figure 3.8-26—Personnel Airlock, Emergency Airlock General Overview

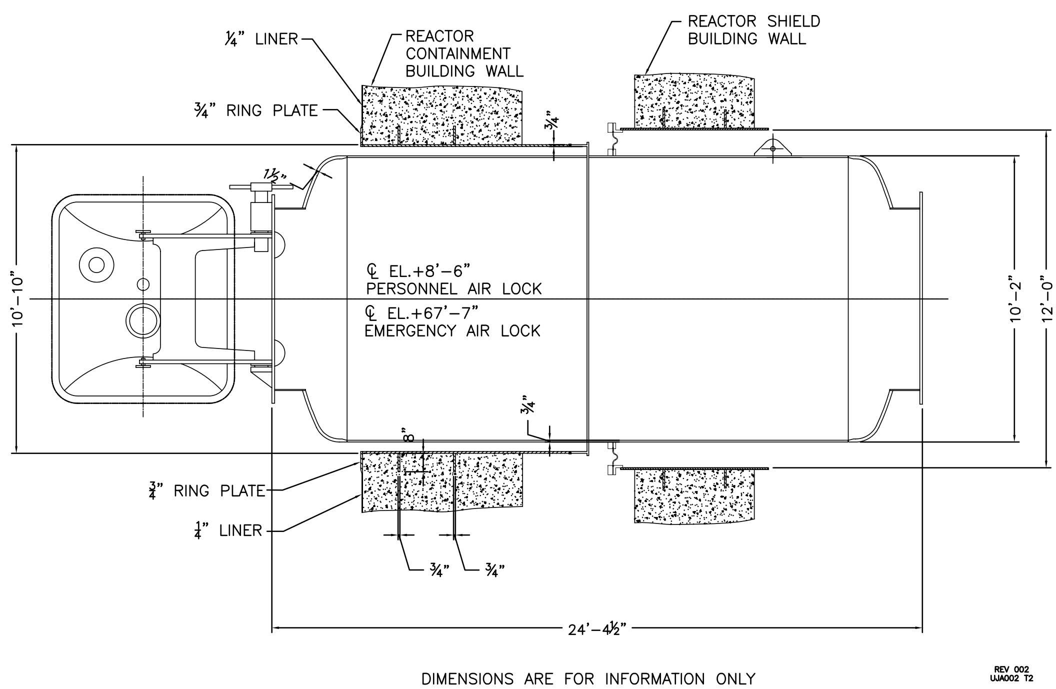

Figure 3.8-27—Containment Penetrations for Main Steam and for Feedwater Pipes

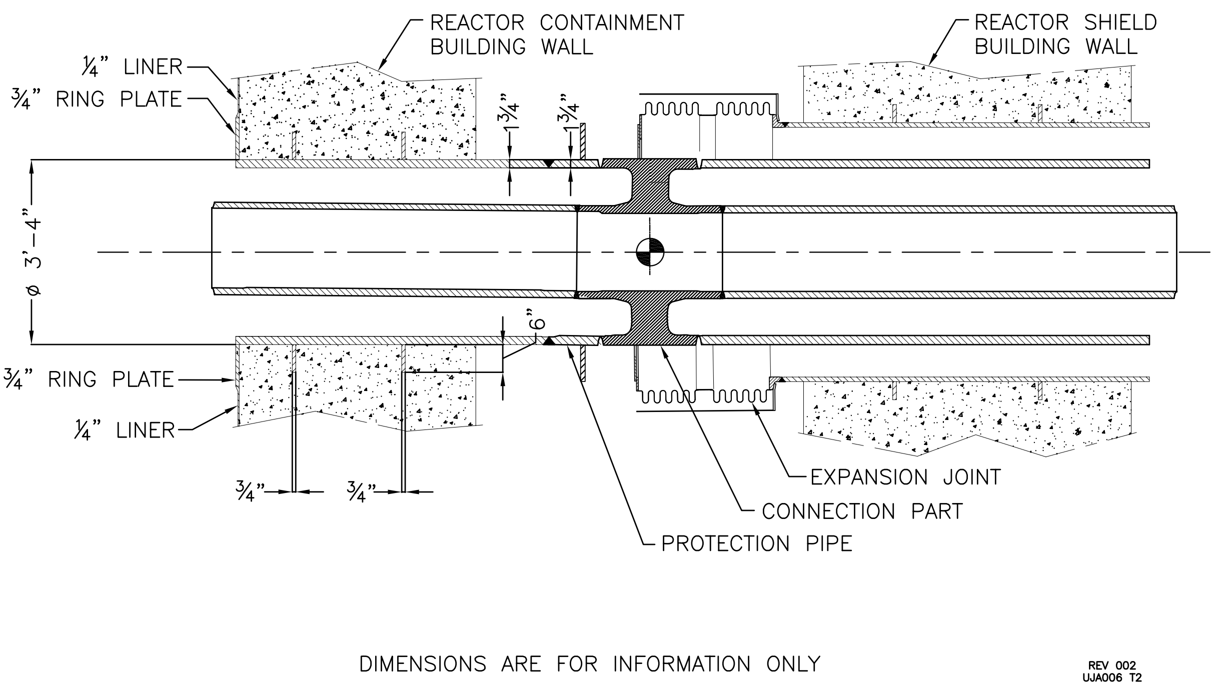

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Figure 3.8-31—Fuel Transfer Tube Penetration (Conceptual View)

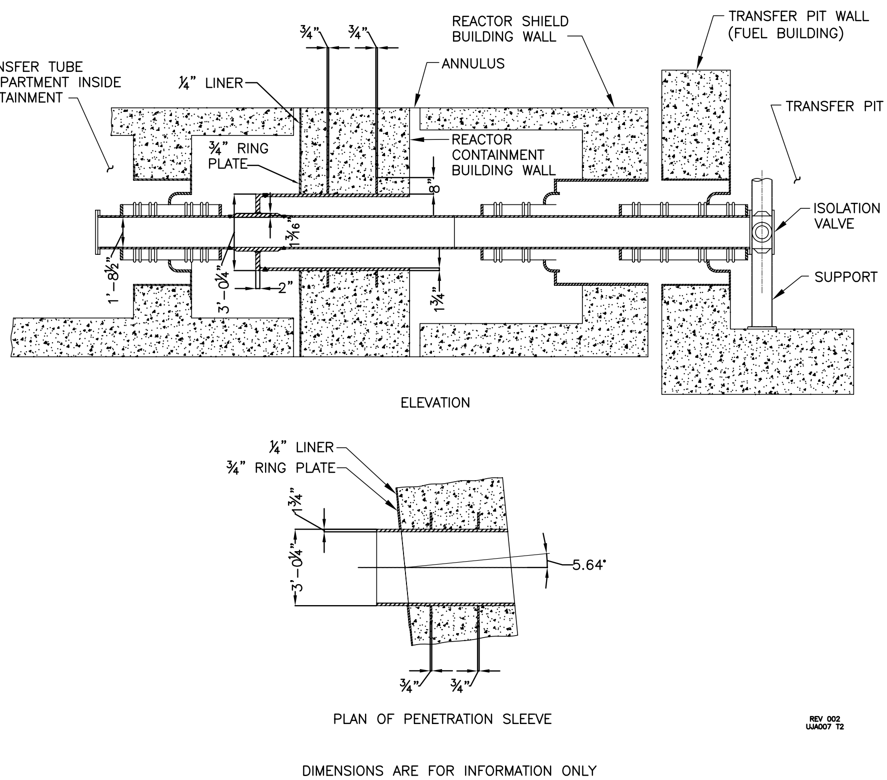

Figure 3.8-120—Containment Penetration for Main Steam Pipe

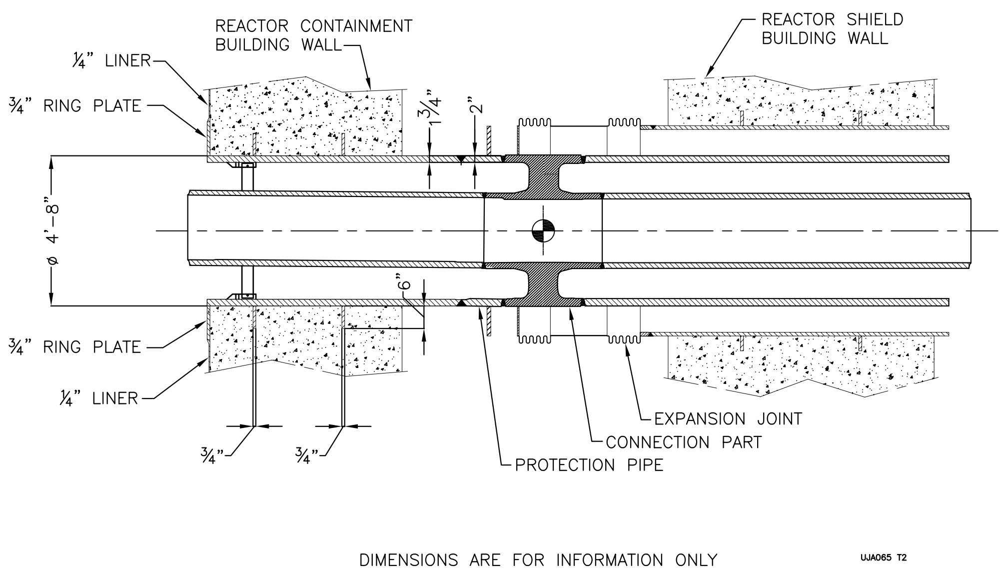

Figure 3.8-121—Low Voltage Electrical Penetration Sleeve

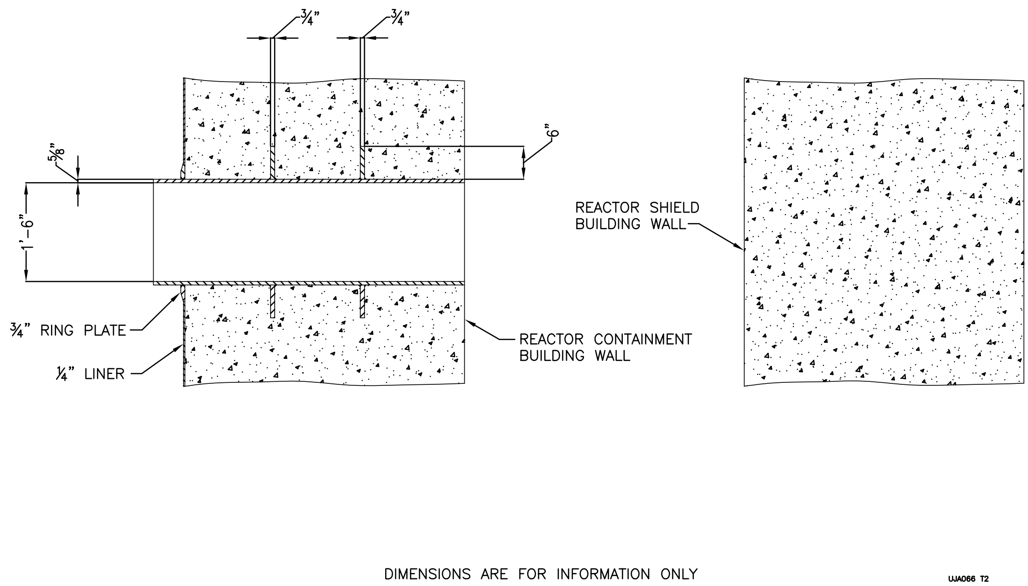

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Figure 3.8-122—Medium Voltage Electrical Penetration Sleeve

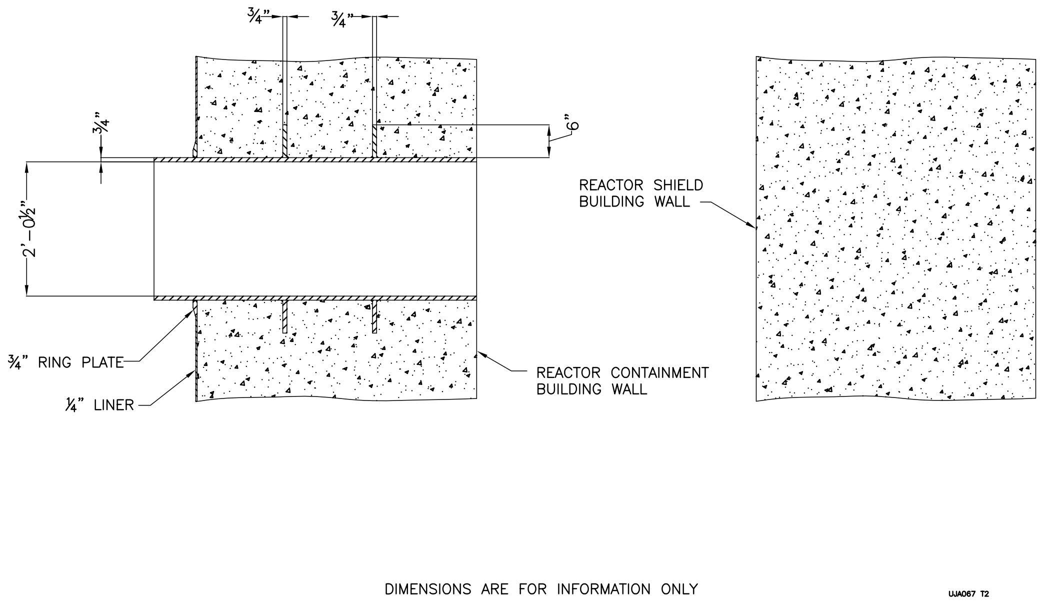

Figure 3.8-123—Construction Opening

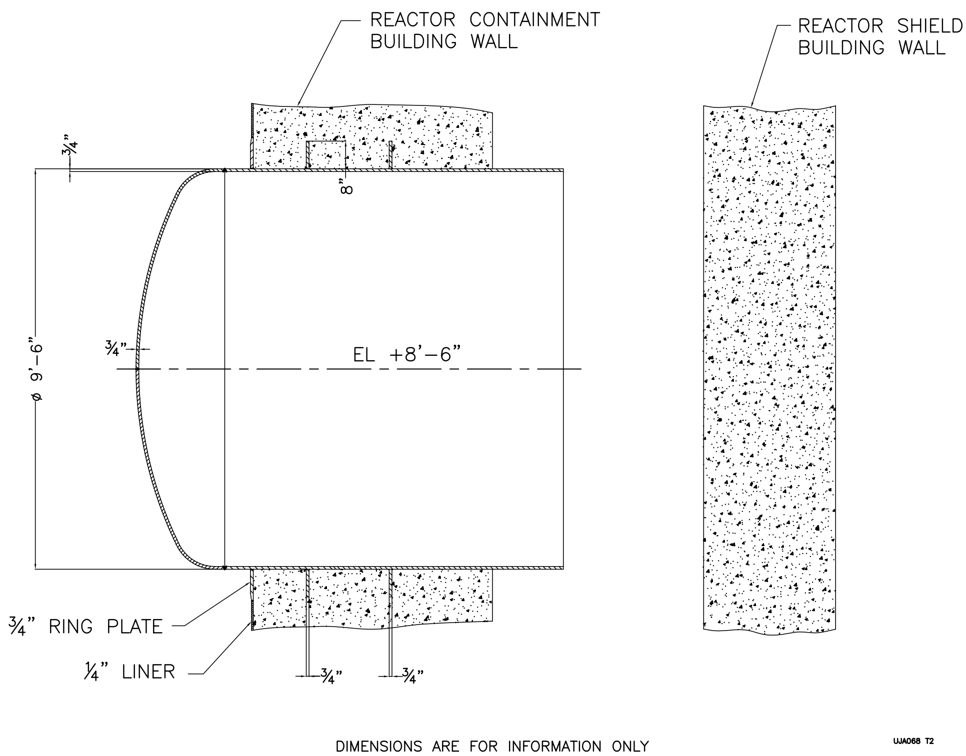

Table 6.1-1—Pressure-Retaining Material Specifications for Engineered Safety Features
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Component	Material
Annulus Ventilation System	
Nuclear grade filtration housing (not in annulus)	ASTM A-240 Type 304 [1, 2]
Ducts, structural steel supports (inside the annulus)	ASTM A-36
Ducts (inside the annulus) stainless steel sheet	ASTM A-167 ASTM A-480
Main control room air conditioning system	
All	Refer to Section 9.4.1
Reactor Building Liner and Penetration Sleeves	
Liner Plate	Carbon Steel SA-516 Grades 55, 60, 65 or 70 (ASME Section III, Division 2, Subsection CC)
Penetration Sleeves • Pipe Material • Plate Material	• Carbon Steel SA-333 Grade 6, SA-106 Grades A, B or C • Austenitic Stainless Steel SA-312 Grades TP304 or TP 304L (ASME Section III, Division 1, Subsection NE) • Carbon Steel SA-516, Gr. 55, 60, 65 or 70, and SA-537 Class 1 or 2 (ASME Section III, Division 1, Subsection NE)
Welding Material • Carbon Steel • Low Alloy Steel • Stainless Steel	• E70XX (SFA-5.1) • ER70S-X[5] or E70C-XC (SFA-5.18)[5] • E7XT-X (SFA-5.20)[5] • E80XX-X (SFA-5.5)[5] • ER80S-XXX[5] or E80C-XXX (SFA-5.28)[5] • E8XTX-X[5] (SFA-5.29)[5] • E308L-XX, E309L-XX or E316L-XX (SFA-5.4) • ER308L, ER309L or ER316L (SFA-5.9) • E308LTX-X[5], E309LTX-X[5] or E316LTX-X (SFA-5.22)[5]
ASME Class MC Components	
Equipment Hatch, Airlocks, and Construction Opening	Carbon Steel SA-516, Grades 55, 60, 65, or 70
Fuel Transfer Tube	

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Table 6.1-1—Pressure-Retaining Material Specifications for Engineered Safety Features Sheet 7 of 7

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Component	Material
• Tube	• SA-240 Type 304[2] SA-240 Type 304L SA-240 Type 304LN SA-240 Type 316[2] SA-240 Type 316L SA-240 Type 316LN
• Tube Flange	• SA-336 Class F304 [2] SA-336 Class F316 [2] SA-336 Class F304LN SA-336 Class F316LN SA-182 Class F304 [2] SA-182 Class F304L SA-182 Class F304LN
• Flange for RB transfer pits expansion bellows	• SA-240 Type 304 [2] SA-240 Type 304L SA-240 Type 304LN SA-240 Type 316 [2] SA-240 Type 316L SA-240 Type 316LN
• Flange at the containment wall	• SA-266 Class 1 SA-266 Class 2
• Cover for flange at the containment wall	• SA-336 Class F304 [2] SA-336 Class F304LN SA-336 Class F316 [2] SA-336 Class F316LN
• Tube portion connected with the anchoring flange	• SA-336 Class F304[2] SA-336 Class F304LN SA-336 Class F316[2] SA-336 Class F316LN

Notes:

1. Solution annealed and rapidly cooled.
2. Carbon not exceeding 0.03 wt%.
3. Quenched and tempered.
4. Piping is seamless.
5. Electrodes with “G” classification are excluded.