ArevaEPRDCPEm Resource

From: Pederson Ronda M (AREVA US) [Ronda.Pederson@areva.com]
Sent: Wednesday, December 17, 2008 6:27 PM
To: Getachew Tesfaye
Cc: PORTER Thomas (EXT); WELLS Russell D (AREVA US); SLIVA Dana (EXT); BENNETT Kathy A (OFR) (AREVA US); DELANO Karen V (AREVA US)
Subject: Response to U.S. EPR Design Certification Application RAI No. 88, FSAR Ch 5, Supplement 1
Attachments: RAI 88 Supplement 1 Response US EPR DC.pdf

Getachew,

AREVA NP Inc. provided responses to 7 of the 15 questions of RAI No. 88 on November 10, 2008. The attached file, "RAI 88 Supplement 1 Response US EPR DC.pdf" provides technically correct and complete responses to 7 of the remaining 8 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 88 Questions 05.02.03-3 and 05.03.02-6.

The following table indicates the respective pages in the response document, "RAI 88 Supplement 1 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 88 — 05.02.03 – 2	2	2
RAI 88 — 05.02.03 – 3	3	3
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RAI 88 — 05.02.03 – 13	8	10
RAI 88 — 05.03.02 – 6	11	11

A complete answer is not provided for 1 of the 15 questions. The schedule for a technically correct and complete response to this question is unchanged and provided below.

Question #	Response Date
RAI 88 — 05.02.03 – 14	January 15, 2009

Sincerely,

Ronda Pederson
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Licensing Manager, U.S. EPR Design Certification
AREVA NP Inc.
An AREVA and Siemens company
3315 Old Forest Road
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From: WELLS Russell D (AREVA NP INC)
Sent: Monday, November 10, 2008 6:39 PM
To: 'Getachew Tesfaye'
Cc: 'John Rycyna'; Pederson Ronda M (AREVA NP INC); BENNETT Kathy A (OFR) (AREVA NP INC); DELANO Karen V (AREVA NP INC)
Subject: Response to U.S. EPR Design Certification Application RAI No. 88, FSAR Ch 5

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 88 Response US EPR DC.pdf " provides technically correct and complete responses to 7 of the 15 questions.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 88 Questions 05.02.03 – 4, 05.02.03 – 5, 05.02.03 – 6, and 05.02.03 – 8.

The following table indicates the respective pages in the response document, "RAI 88 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 88 — 05.02.03 – 1	2	2
RAI 88 — 05.02.03 – 2	3	3
RAI 88 — 05.02.03 – 3	4	4
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RAI 88 — 05.02.03 – 13	15	15
RAI 88 — 05.02.03 – 14	16	16
RAI 88 — 05.03.02 – 6	17	17

A complete answer is not provided for 8 of the 15 questions. The schedule for a technically correct and complete response to this question is provided below.

Question #	Response Date
RAI 88 — 05.02.03 – 2	December 17, 2008
RAI 88 — 05.02.03 – 3	December 17, 2008
RAI 88 — 05.02.03 – 9	December 17, 2008
RAI 88 — 05.02.03 – 10	December 17, 2008
RAI 88 — 05.02.03 – 11	December 17, 2008
RAI 88 — 05.02.03 – 13	December 17, 2008
RAI 88 — 05.02.03 – 14	January 15, 2009
RAI 88 — 05.03.02 – 6	December 17, 2008

Sincerely,

(Russ Wells on behalf of)
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From: Getachew Tesfaye [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Thursday, October 09, 2008 4:10 PM
To: ZZ-DL-A-USEPR-DL
Cc: Robert Davis; Nihar Ray; David Terao; Tarun Roy; Joseph Colaccino; John Rycyna
Subject: U.S. EPR Design Certification Application RAI No. 88 (1239, 1044),FSAR Ch. 5

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 16, 2008, and discussed with your staff on October 9, 2008. Draft RAI Question 05.02.03-14 was modified as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
(301) 415-3361

Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 61

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Response to

Request for Additional Information No. 88 Supplement 1 (1239, 1044), Revision 0

10/9/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 05.02.03 - Reactor Coolant Pressure Boundary Materials
SRP Section: 05.03.02 - Pressure-Temperature Limits, Upper-Shelf Energy, and Pressurized Thermal Shock
Application Section: FSAER Ch. 5

QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)

Question 05.02.03-2:

The RCPB materials specified in Table 5.2-2 for the CRDM lists SA-312 Grade 347 as one of the materials used for the pressure housing. The staff notes that Grade 347 material is not listed in Section II material specification SA-312 although the staff notes that Grade TP347 is listed. In addition, under pressurizer components, the applicant has listed SA-213 Type 316L material. Material Type 316L does not appear in SA-213 although material Grade TP 316L is listed. The staff requests that the applicant modify Table 5.2-2 to list the appropriate material grades consistent with the applicable material specifications.

Response to Question 05.02.03-2:

The material for the control rod drive mechanism has been changed to SA-312 Grade TP347 in Table 5.2-2. See Question 05.02.03-3 for FSAR Table 5.2-2 updates.

The material for the pressurizer has been deleted from the table, as updated per Question 05.02.03-3. This material pertains to an appurtenance of the pressurizer and not the pressurizer itself.

FSAR Impact:

See the response to Question 05.02.03-3.

Question 05.02.03-3:

Table 5.2-2 lists several material specifications and grades for the RCPB piping, steam generator, pressurizer, reactor coolant pump and CRDM components. The applicant did not however identify the individual components that will be fabricated from each material specification. In order for the staff to complete its review of the RCPB materials, the staff requests that the applicant modify Table 5.2-2 to list the components fabricated with each material specification. For example, the specifications listed for the steam generators should identify which specification is used for the shell, heads, tubesheet, nozzles, etc. The Table 5.2-2 entry for the pressurizer safety relief valves should list all valve components that perform a pressure boundary function (valve bonnet, bolting etc.). In addition, the staff requests that the applicant identify weld filler materials used to weld the various material types and combinations.

Response to Question 05.02.03-3:

The materials in U.S. EPR FSAR, Tier 2, Table 5.2-2 have been updated to list the components fabricated with each material specification including filler materials.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 5.2-2 will be revised as described in the response and indicated on the enclosed markup.

Question 05.02.03-9:

FSAR Section 5.2.3.4.1 indicates that unstabilized austenitic stainless steels contain less than 0.03 wt% carbon but Table 5.2-2 does not limit carbon to less than 0.03% for all unstabilized carbon steels. For example, under RCPB piping in Table 5.2-2, the applicant has specified ASME SA-312 Grade TP304L but does not list Table 5.2-2 Note 3 which limits carbon to less than 0.03%. SA-312 Grade TP304L specifies a maximum carbon content of 0.035%. The staff requests that the applicant modify Table 5.2-2 to be consistent with FSAR Section 5.2.3.4.1.

Response to Question 05.02.03-9:

See the response to Question 05.02.03-3.

FSAR Impact:

See the response to Question 05.02.03-3.

Question 05.02.03-10:

FSAR Sections 5.3 and 3.6.3 indicate that dissimilar metal welds (DMWs) joining low alloy steel nozzles and stainless steel safe ends will use the GTAW process with a narrow groove weld joint design and no weld buttering of low alloy steel nozzles. The staff requests the following information in order for the staff to complete its review.

1. Discuss development and testing programs that AREVA has performed on narrow groove welding of nozzle to safe ends without first applying a buttering layer.
2. Discuss the PWHT procedures used in welding procedure qualification testing and those proposed to be used during fabrication. In addition, discuss any nontraditional PWHT regimes and discuss their adequacy.
3. Discuss typical HAZ impact test values (Charpy and mills lateral expansion) obtained during welding procedure qualification and discuss controls on welding to ensure that production welds will have similar fracture toughness to the fracture toughness testing results from welding procedure qualifications.
4. Discuss welding process controls employed to reduce weld metal dilution in order to retain the maximum percentage of Chromium possible in order to decrease the susceptibility of components to stress corrosion cracking for the life of the plant.

Response to Question 05.02.03-10:

1. Based on experience, AREVA has developed a process which improves microstructure to enhance the mechanical properties at the interface, reduces the risk of cold cracking due to the martensitic layer at the fusion line of the buttering, and reduces the risk of intergranular corrosion sensitization of the austenitic SS first layer due to carbon diffusion.

To improve the weld, AREVA developed an Alloy 82 DMW in which the buttering was performed by hot wire gas tungsten arc welding (GTAW) with Alloy 82, the weld used Alloy 82, and the DMW was given a post-weld heat treatment (PWHT). This process improved the weld solution since there was no martensitic microstructure potentially sensitive to hydrogen cold-cracking, and the mechanical properties also significantly increased compared to the previous process.

AREVA NP has gained experience with GTAW narrow gap welding of stainless steel primary piping and developed a narrow gap welding process for DMW. AREVA NP has improved the welding procedure by achieving, in a narrow groove, a one-pass-per-layer weld totally comprised of Alloy 52. The microstructure and properties of this type of DMW were studied on several full scale mock ups, as a function of the PWHT. A detailed description of the microstructure close to the fusion line was collected along with the influence of the PWHT; extensive mechanical testing was also performed at the interface. The mechanical testing results showed that the Charpy impact toughness depends on the position of the notch. Even when the crack tip is located in the lowest Charpy toughness zone, the equivalent reference temperature for the nil ductility transition (RT_{NDT}) deduced from fracture toughness tests is below the specified RT_{NDT} of the neighboring low alloy ferritic material.

Alloy 52 is resistant to primary water stress corrosion cracking (PWSCC). Additionally, tests were performed to demonstrate the resistance to PWSCC of the interface between Alloy 52 and the 308L cladding of the low alloy steel. Corrosion tests, including very severe reverse U-bend (RUB) tests in primary water at 680°F, which sampled the weld metal itself and the interface

with 308L, did not show crack initiation after 10,000 hours. The tests demonstrated the metallurgical quality of the GTAW narrow gap Alloy 52 DMW.

2. The results of a weld development study for the U.S. EPR dissimilar metal welds will be available later in the design process. The PWHT procedure used for the welding qualification will be representative of the procedure used for manufacturing. It is not intended to employ any nontraditional heat treatment regimes.

3. The results of a weld development study for the U.S. EPR dissimilar metal welds will be available later in the design process. Procedure qualifications and weld procedures are not yet developed; therefore, HAZ impact test values will be available later in the design process.

4. Welding procedures will be developed for U.S. EPR dissimilar metal welds later in the design process. Qualification of these procedures will include consideration of weld metal dilution level and the maximum percentage of residual acceptable chromium.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 05.02.03-11:

FSAR Section 5.3 indicates that Alloy 690 CRDM adapters are welded to the RPV head using Alloy 52/52M/152. The partial penetration j-groove joint design can be difficult to weld given the highly restrained nature of the joint design and the limited accessibility for the welder. The staff notes that recently fabricated RPV replacement heads have required extensive welding repairs during fabrication. In addition, large numbers of welding flaws have been identified during baseline UT examination of CRDM nozzles. Given the susceptibility of Alloys 52, 52M and 152 to ductility dip cracking and other types of welding flaws in partial penetration j-groove welds, the staff requests that the applicant discuss its welding process controls to minimize welding flaws in CRDM adapter to RPV head welds and any other partial penetration welds that involve dissimilar materials within the RCPB. In addition, discuss welding process controls employed to reduce weld metal dilution in order to retain the maximum percentage of Chromium possible in order to decrease the susceptibility of components to stress corrosion cracking for the life of the plant.

Response to Question 05.02.03-11:

To reduce the risk of weld cracking, AREVA NP developed a specific method to test welding products for different type of welding flaws (labeled “hot cracks”). This method consists of building up a multi-pass gas tungsten arc welding or manual metal arc welding (MMAW) weld in circular groove, which has a high degree of mechanical constraint. The degree of constraint and the nature of the base metal of the test block are varied depending on the severity of the representative case. The test is analyzed for the number and types of cracks. It is thus possible to test batches of welding products in a specific condition representative of (or even more severe in terms of mechanical constraint, base metal, and dilution) specific applications, such as control rod drive mechanism (CRDM) J-groove welds and reactor pressure vessel DMWs. At the research and development stage, this test method allows for sorting welding products and suppliers and is a guide for selection of new welding products. At the implementation stage, the product specification includes a specific test of sensitivity to hot cracking that is used as a reception test. If the test acceptance criteria are not met, the product is rejected.

The level of chromium in dissimilar metal weld metal in contact with primary water is sufficient to prevent PWSCC crack initiation, as demonstrated by AREVA NP testing. The reproducibility of the welding process, and thus of the dilution of chromium, is addressed by the procedure qualification of the welding process.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Question 05.02.03-13:

Cold work and residual stress imparted on components fabricated from austenitic stainless steels and nickel based alloys has contributed to stress corrosion cracking in several currently operating PWRs and BWRs. The staff requests that the applicant describe special fabrication process requirements employed to limit the effects of cold work and residual stress, caused by grinding/repair or other fabrication processes on surfaces that come into contact with RCS fluids in order to minimize the susceptibility of components to stress corrosion cracking for the design life of the plant.

Response to Question 05.02.03-13:

Experiments performed by AREVA NP, along with internationally published data, shows that Alloys 52 and 152, as well as the 308L stainless steel cladding-to-Alloy 52 interface, do not exhibit PWSCC crack initiation sensitivity, even when tested with reverse U-bend or constant rate extension tests specimens, though it is known that these test specimens induce a very high level of plastic strain (i.e., cold work). This shows that Alloys 52 and 152 are intrinsically resistant to primary water stress corrosion cracking, even in cases of cold work. Cold working induced by grinding or other processes does not induce stress corrosion cracking sensitivity of stainless steel base metals or welds in contact with primary water. Operating experience shows that when surface contamination is avoided and when water pollution is prevented, stainless steels are not sensitive to stress corrosion cracking in primary water, even when cold-working has occurred.

Table 05.02.03-13-1 showing the reactor coolant pressure boundary components and the fabrication processes employed to limit the effects of cold work and residual stresses.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Table 05.02.03-13-1: Fabrication Processes to Limit Cold work and Residual Stresses

Component	Fabrication Processes to Limit Cold work and Residual Stresses
NSSS components (steam generator, reactor pressure vessel, pressurizer, reactor coolant pump, piping)	Alloy 600 and its associated weld metals (Alloy 82 and Alloy 182), known for their sensitivity to stress corrosion cracking, are prohibited for the fabrication of the nuclear steam supply system components. All parts previously made of Alloy 600 are replaced with thermally treated Alloy 690 and its associated weld metals (Alloy 52, 52M, and 152). Weld repair of forgings by the forging supplier is prohibited. Weld repairs are limited to the extent practical. Where necessary, weld repair of dissimilar metal welds in contact with primary fluids are performed using repair methods selected to achieve compressive (or as low as reasonably achievable tensile) stress conditions on the wetted inner surface. Tools, such as abrasive wheels, discs, sanders, blenders, and files, used for metal removal/finishing shall be visibly clean, not contain loose material, and may not have been used on aluminum, copper, lead or its compounds, or other low melting metals. This does not include machining tools, including drill bits, end mills, and lathes. Abrasive tools used on austenitic stainless steels have not been previously used on any other material.
Reactor Pressure Vessel	The Alloy 52/52M/152 partial penetration welds in high-stress joints, such as reactor pressure vessel head penetrations, are polished with a flap wheel after grinding. This process reduces roughness, removes the surface with the highest cold work induced by grinding, and leaves compressive residual stresses at the surface.

Component	Fabrication Processes to Limit Cold work and Residual Stresses
Steam Generator Tubing	The straightening performed on the steam generator (SG) tubing will not increase the yield strength by more than 13.1ksi, as demonstrated by tensile tests on tube material after mill annealing and after final strengthening. Grinding of the tubing is done after final mill annealing and before thermal treatment. The grinding does not result in surface residual stresses higher than 20 ksi tensile prior to thermal treatment. No machine re-straightening or grinding is performed after the final thermal treatment or nondestructive testing. However, machine re-straightening or regrinding is permitted after thermal treatment if it is followed by an additional two hour period of thermal treatment and all non-destructive examination tests are also repeated. After final annealing, straightening, and grinding, the tubing is heat treated at 1320°F (+40°F, -0°F) for a minimum of 10 hours. The furnace atmosphere is vacuum, helium, or argon, and will not result in deleterious changes in the composition of the inside or outside diameter tube surfaces (decarburizing, carburizing, or nitriding), as shown by metallurgical examination. The buffing process is qualified by the tubing supplier and demonstrates that, by x-ray measurements, the peaks in tensile stress are less than +5 ksi. The qualification also demonstrates that there are no changes to mechanical or microstructural tube properties. U-bends with a bend radius up to and including 11.5 inches are stress relieved for a minimum of 2 hours at 1320°F (+40°F, -0°F). No weld repairs on the SG tubing are performed.
Steam Generator Tube to Tubesheet	Hydraulic expansion with a smooth transition zone (special attention is paid to the taper profile) is required to decrease the residual stresses on tube outside diameter (OD) and inside diameter (ID) to the minimum possible extent. This is achieved with the expansion process and the reduced and tightly controlled gap between the tube ODs and the tubesheet hole IDs. Industrial data from long term and accelerated corrosion tests demonstrating that outside diameter stress corrosion cracking and primary water stress corrosion cracking will be precluded are available. Those results are confirmed by a recirculating steam generator trouble-free operating experience of over eighteen years.
Control Rod Drive Mechanism	The cold worked austenitic stainless steel material used for the control rod drive mechanism has a yield strength that does not exceed 90 ksi. Abrasive work on austenitic stainless steels is adequately controlled to prevent contamination by materials that may promote stress corrosion cracking. Tools used on austenitic stainless steel surfaces do not contained, nor have been previously used on such materials (i.e., carbon steel).

Question 05.03.02-6:

In Table 1.8-2, "U.S. EPR Combined License Information Items," the applicant did not provide an action for the COL applicant to provide its plant-specific pressurized thermal shock (RT_{PTS}) values for vessel beltline materials. Please add another item under Item No. 5.3-2 (Table 1.8-2) stating "A COL applicant that references the U.S. EPR design certification will provide plant-specific RT_{PTS} values in accordance with 10 CFR 50.61 for vessel beltline materials."

Response to Question 05.03.02-6:

U.S. EPR FSAR, Tier 2, Chapter 1 Table 1.8-2 and Section 5.3.2.3 will be revised to require a COL applicant to provide plant-specific RT_{PTS} values in accordance with 10 CFR 50.61 for vessel beltline materials.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Chapter 1 Table 1.8-2 and Section 5.3.2.3 will be revised as described in the response and indicated on the enclosed mark-up.

U.S. EPR Final Safety Analysis Report Markups

Table 1.8-2—U.S. EPR Combined License Information Items
Sheet 21 of 42

Item No.	Description	Section	Action Required by COL Applicant	Action Required by COL Holder
5.2-2	A COL applicant that references the U.S. EPR design certification will identify additional ASME code cases to be used.	5.2.1.2	Y	
5.2-3	A COL applicant that references the U.S. EPR design certification will identify the implementation milestones for the site-specific ASME Section XI preservice and inservice inspection program for the reactor coolant pressure boundary, consistent with the requirements of 10 CFR 50.55a (g). The program will identify the applicable edition and addenda of the ASME Code Section XI, and will identify additional relief requests and alternatives to Code requirements.	5.2.4	Y	
5.3-1	A COL applicant that references the U.S. EPR design certification will identify the implementation milestones for the material surveillance program.	5.3.1.6	Y	
5.3-2	A COL applicant that references the U.S. EPR design certification will provide a plant-specific pressure and temperature limits report (PTLR), consistent with an approved methodology.	5.3.2.1		Y
5.3-3	A COL applicant that references the U.S. EPR design certification will provide plant-specific RT_{PTS} values in accordance with 10 CFR 50.61 for vessel beltline materials.	5.3.2.3		Y
5.4-1	A COL applicant that references the U.S. EPR design certification will identify the edition and addenda of ASME Section XI applicable to the site specific Steam Generator inspection program.	5.4.2.5.2.2	Y	05.03.02-6
6.1-1	A COL applicant that references the U.S. EPR design certification will review the fabrication and welding procedures and other QA methods of ESF component vendors to verify conformance with RGs 1.44 and 1.31.	6.1.1.1	Y	

05.02.03-3

Table 5.2-2—Material Specifications for RCPB Components
Sheet 1 of 4

Component	Material
RCPB Piping	
~~Piping, fittings, and nozzles~~	~~ASME SA-312 Grade TP304L (see Note 3)~~ ~~ASME SA-312 Grade TP304LN (see Note 3)~~ ~~ASME SA-312 Grade TP316L (see Note 3)~~ ~~ASME SA-312 Grade TP316LN (see Note 3)~~ ~~ASME SA-376 Grade TP304LN (see Note 3)~~ ~~ASME SA-182 Grade F304LN (see Note 3)~~ ~~ASME SA-336 Grade F304LN (see Note 3)~~
~~Welds~~	~~Type 304L/308L/309L/316L austenitic stainless steel~~ ~~Alloy 52/52M or Alloy 152~~
Reactor coolant piping & surge line	ASME SA-182 Grade F304 (see Notes 3 & 4) ASME SA-336 Grade F304 (see Notes 3 & 4)
Reactor coolant piping & surge line fittings & nozzles	ASME SA-182 Grade F304 (see Notes 3 & 4) ASME SA-336 Grade F304 (see Notes 3 & 4)
Reactor coolant piping other than loop & surge line	ASME SA-213 Grade TP304L (Seamless) (see Note 3 & 4) ASME SA-312 Grade TP304L (Seamless) (see Note 3 & 4) ASME SA-312 Grade TP316LN (Seamless) (see Note 3 & 4)
Reactor coolant piping fittings & nozzles other than loop & surge line fittings & nozzles	ASME SA-182 Grade F304L (see Note 3) ASME SA-182 Grade F316LN (see Notes 3 & 4) ASME SA-403 Grade WP304L Class S (see Notes 3 & 4) ASME SA-403 Grade WP316LN Class S (see Notes 3 & 4)
Steam Generators	
~~Components~~	~~ASME SA-508 Grade 3 Class 2 (see Note 1)~~ ~~ASME SB-168 Alloy 690 (see Note 2)~~ ~~ASME SA-182 Grade F316LN (see Note 3)~~ ~~ASME SA-336 Grade F316LN (see Note 3)~~ ~~ASME SA-105 (see Note 6)~~ ~~ASME SA-182 Grade F304L (see Note 3)~~ ~~ASME SB-163 Alloy 690 (see Note 2)~~ ~~ASME SA-193 Grade B16 (see Note 1)~~ ~~ASME SA-194 Grade 16 or 7 (see Note 1)~~
~~Welds~~	~~Type 304L/308L/309L/316L austenitic stainless steel~~ ~~Carbon steel~~ ~~Alloy steel~~ ~~Alloy 52/52M or Alloy 152~~
Pressure boundary forgings (including shells, heads, tubesheet, nozzles, & openings)	ASME SA-508 Grade 3 Class 2 (see Note 1)
Small nozzles	ASME SA-105 (see Note 6)

05.02.03-3

Table 5.2-2—Material Specifications for RCPB Components
Sheet 2 of 4

Component	Material
Secondary nozzle safe ends (except emergency feedwater nozzle safe end)	ASME SA-508 Grade 3 Class 1 (see Note 1)
Emergency feedwater nozzle safe end	ASME SA-403 Grade WP316L (Seamless) (see Notes 3 & 4) ASME SA-182 Grade F316L (see Note 3)
Inlet & outlet nozzle safe ends	ASME SA-182 Grade F316 (see Notes 3 & 4) ASME SA-336 Grade F316 (see Notes 3 & 4)
Tubes	ASME SB-163 Alloy 690 (see Note 2)
Openings covers (for manways, inspection holes, & handholes)	ASME SA-533 Type B Class 2 (see Note 1)
Openings studs (for manways, inspection holes, & handholes)	ASME SA-193 Grade B16 (see Note 1) ASME SA-193 Grade B7 (see Note 1)
Primary manway studs	ASME SA-193 Grade B16 (see Note 1)
Openings nuts (for manways, inspection holes, & handholes)	ASME SA-193 Grade B16 (see Note 1) ASME SA-193 Grade B7 (see Note 1)
Pressurizer	
~~Components~~	~~ASME SA-508 Grade 3 Class 2 (see Note 1)~~ ~~ASME SA-533 Type B Class 2 (see Note 1)~~ ~~ASME SA-182 Grade F316LN (see Note 3) or~~ ~~ASME SA-336 Grade F316LN (see Note 3)~~ ~~ASME SA-312 Grade TP316L (see Note 3)~~ ~~ASME SA-479 Type 316LN (see Note 3)~~ ~~ASME SA-213 Type 316L (see Note 3)~~ ~~ASME SA-240 Type 304L (see Note 3)~~ ~~ASME SA-193 Grade B16 (see Note 1)~~ ~~ASME SA-194 Grade 16 (see Note 1)~~
~~Welds~~	~~Type 304L/308L/309L/316L austenitic stainless steel~~ ~~Alloy steel~~ ~~Alloy 52/52M or Alloy 152~~
Upper head	ASME SA-508 Grade 3 Class 2 (see Note 1)
Bottom head	ASME SA-508 Grade 3 Class 2 (see Note 1)
Cylindrical shells	ASME SA-508 Grade 3 Class 2 (see Note 1)
Manway	ASME SA-508 Grade 3 Class 2 (see Note 1)
Manway cover	ASME SA-533 Type B Class 2 (see Note 1)
Surge nozzle	ASME SA-508 Grade 3 Class 2 (see Note 1)
Safety valve nozzles	ASME SA-508 Grade 3 Class 2 (see Note 1)
Spray nozzles	ASME SA-508 Grade 3 Class 2 (see Note 1)
Venting nozzle	ASME SA-508 Grade 3 Class 2 (see Note 1)

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Table 5.2-2—Material Specifications for RCPB Components
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Component	Material
Primary depressurization system valve nozzle	ASME SA-508 Grade 3 Class 2 (see Note 1)
Safe ends: • Spray nozzle • Surge nozzle • Safety valve nozzle • Primary depressurization system valve nozzle Nozzles: • Temperature measurement • Level measurement • Sample	ASME SA-182 Grade F316 (see Notes 3 & 4) ASME SA-336 Grade F316 (see Notes 3 & 4)
Heater sleeves	ASME SA-182 Grade F316 (see Notes 3 & 4) ASME SA-336 Grade F316 (see Notes 3 & 4)
Vent nozzle safe ends	ASME SA-182 Grade F316 (see Notes 3 & 4)
Vent manway nozzle	ASME SA-182 Grade F316 (see Notes 3 & 4)
Valve pilot nozzle	ASME SA-182 Grade F316 (see Notes 3 & 4)
Manway studs	ASME SA-193 Grade B16 (see Note 1)
Manway nuts	ASME SA-194 Grade 16 (see Note 1)
Reactor Coolant Pump	
~~Components~~	~~ASME SA-182M Grade F304 (see Notes 3 & 4)~~ ~~ASME SA-182M Grade F316 (see Notes 3 & 4)~~ ~~ASME SA-193M Grade B7 (see Note 1)~~ ~~ASME SA-194M Grade 7 (see Note 1)~~ ~~ASME SA-213M Grade TP316 (see Notes 3 & 4)~~ ~~ASME SA-216M Grade WCC~~ ~~ASME SA-312M Grade TP304 (see Notes 3 & 4)~~ ~~ASME SA-351M Grade CF3 (see Notes 3 & 5)~~ ~~ASME SA-453M Grade 660 Class B (see Note 7)~~ ~~ASME SA-479M Type 304 (see Notes 3 & 4)~~ ~~ASME SA-508M Grade 3 Class 2 (see Note 1)~~ ~~ASME SA-540M Grade B24 Class 1 (see Note 1)~~ ~~ASME SA-540M Grade B24 Class 3 (see Note 1)~~ ~~ASME SA-705M Type 630 H1150 (see Note 7)~~
~~Welds~~	~~Type 308L/316L austenitic stainless steel~~
Pressure forgings	ASME SA-182M Grade F304 (see Notes 3 & 4)
Cooler tubes	ASME SA-213M Grade TP316 (see Notes 3 & 4)
Support stand flange – integral part of casing closure bolted assembly	ASME SA-216M Grade WCC
Pressure casting	ASME SA-351M Grade CF3 (see Notes 3 & 5)

~~Next File~~

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Table 5.2-2—Material Specifications for RCPB Components
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Component	Material
Bolting	ASME SA-453M Grade 660 Class B (see Note 7)
Thermowell	ASME SA-479M Type 304 (see Notes 3 & 4)
Flange – integral part of pressure boundary casing closure bolted assembly	ASME SA-508M Grade 3 Class 2 (see Note 1)
Pressure boundary stud bolts & nuts	ASME SA-540M Grade B24 Class 1 (see Note 1)
Pressure boundary casing closure stud & nuts	ASME SA-540M Grade B24 Class 3 (see Note 1)
Shaft seal pressure boundary parts	ASME SA-705M Type 630 H1150 (see Note 7)
Pressure boundary welds	SFA 5.4 E308L SFA 5.4 E316L SFA 5.9 ER316L
Control Rod Drive Mechanism	
~~Pressure Housing~~	~~ASME SA-479 Grade 347 (see Note 3)~~ ~~ASME SA-479/SA-182 Grade F6NM (see Note 1) (UNS S41500)~~ ~~ASME SA-312 Grade 347 (see Note 3)~~ ~~ASME SA-453 Grade 660 (see Note 7)~~ ~~ASME SA-437 Grade B4C (see Note 1)~~
~~Welds~~	~~Alloy 52/52M or Alloy 152~~ ~~Type 347 austenitic stainless steel~~
Flange, connection piece, head, loose flange	ASME SA-479 Grade 347 (see Note 3)
Latch housing	ASME SA-479/SA-182 Grade F6NM (see Note 1) (UNS S41500)
Seamless tube	ASME SA-312 Grade TP347 (Seamless) (see Note 3)
Bolt	ASME SA-453 Grade 660 (see Note 7)
Nut	ASME SA-437 Grade B4C (see Note 1)
Welding filler material	SFA 5.4 E347 SFA 5.9 ER347 SFA 5.14 ERNiCrFe-7 SFA 5.14 ERNiCrFe-7A
Pressurizer Safety Relief Valves	
~~Valve Body~~	~~SA-182 or SA-351 austenitic stainless steel~~
A vendor for the PSRV has not been chosen for the U.S. EPR	

Notes on Table 5.2-2

1. Quenched and tempered

exceeded. The initial RT_{NDT}, final predicted RT_{NDT} or adjusted reference temperature (ART), and the copper and nickel contents for materials in the RPV beltline are provided in Table 5.3-3 and Table 5.3-4. The fluence attenuation to the 1/4T and 3/4T locations and the ART values are calculated per RG 1.99, Revision 2.

Generic heatup and cooldown curves are provided in Figure 5.3-1—Reactor Coolant System Heatup Pressure-Temperature Curve and Figure 5.3-2—Reactor Coolant System Cooldown Pressure-Temperature Curve. A COL applicant that references the U.S. EPR design certification will provide a plant-specific pressure and temperature limits report (PTLR), consistent with an approved methodology.

5.3.2.2 Operating Procedures

Plant operating procedures provide reasonable assurance that the P-T limits identified in Section 5.3.2.1 will not be exceeded during conditions of normal operation, AOOs and system hydrostatic tests. The transient conditions considered in the design of the RPV, as presented in Section 3.9.1.1, are representative of the operating conditions considered to occur during plant operation. The selected transients form a conservative basis for evaluation of the RCS and do not result in pressure-temperature changes that exceed the heatup and cooldown rate limits used in the development of the Pressure-Temperature Limit curves of Section 5.3.2.1

5.3.2.3 Pressurized Thermal Shock

The RPV design provides protection against unstable crack growth under faulted conditions. A safety injection actuation following an emergency or faulted event produces relatively high thermal stresses in regions of the RPV contacting the cooler water from the safety injection system. Consideration is given to these areas, including the beltline region and the RPV nozzles, which provide reasonable assurance of RPV integrity under these postulated transients.

An analysis was performed to determine the RPV pressurized thermal shock reference temperatures (RT_{PTS}) applicable to 60 EFPY. The RT_{PTS} values were conservatively calculated for various RPV materials over 60 EFPY with the most limiting core design. These values, calculated in accordance with 10 CFR 50.61 and presented in Table 5.3-4, do not exceed the screening criteria. A COL applicant that references the U.S. EPR design certification will provide plant-specific RT_{PTS} values in accordance with 10 CFR 50.61 for vessel beltline materials.

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5.3.2.4 Upper-Shelf Energy

The minimum Charpy upper-shelf energy values for RPV beltline materials, which meet the requirement of paragraph IV.A.1.a of Appendix G, are specified in Section 5.3.1.5.