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Subject: AP1000 Response to Request for Additional Information (SRP 5)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 5. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP5.2.3-CIB1-01 R3

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification.. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Strategy

/Enclosure

1. Response to Request for Additional Information on SRP Section 5

D063
NRD

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 5

RAI Response Number: RAI-SRP5.2.3-CIB1-01
Revision: 3

Questions (Revision 0):

Revision 17 revised Section 5.2.3.1 of the AP1000 DCD, Tier 2, to include ASME Code Filler Metal Specifications SFA 5.1 and 5.17 for carbon steel, ASME Code Filler Metal Specification SFA 5.22 for stainless steel, and ASME Code Filler Metal Specification SFA 5.30 for consumable inserts. The staff has the following concerns regarding the addition of these filler metal specifications:

1) ASME Code Filler Metal Specifications SFA 5.1 and 5.17 is proposed to be used for welding AP1000 carbon steel reactor coolant pressure boundary components listed in Table 5.2-1 of the AP1000 DCD, Tier 2. In reviewing Table 5.2-1, the pressure forgings (including nozzles and tubesheets for the steam generator) has an option to use carbon steel (SA-508, Class 1A) instead of alloy steel (SA-508, Grade 3, Class 2) and the pressure forgings for the reactor coolant pump has an option to use carbon steel (SA-508, Grade 1) instead of stainless steel (SA-336, Grades F304, F304L, F304LN, F316, F316L and F316LN).

   a. The ASME Code Filler Metal Specifications SFA 5.1 and 5.17 and the associated carbon steel base materials are not typical for this application due to the incompatibility of these materials with the reactor coolant. In addition, the reactor coolant pump flywheel analysis (Curtiss-Wright Electro-Mechanical Corporation Report AP1000 RCP-06-009-P) assumed the reactor coolant pump pressure boundary material to be stainless steel. The flywheel analysis does not include a carbon steel reactor coolant pump pressure boundary, and therefore a flywheel analysis using a carbon steel pressure boundary would be required to be performed.

   b. ASME Code Filler Metal Specifications SFA 5.22 allows the use of fluxed cored filler metal to be used for welding the root pass in all stainless steel reactor coolant pressure boundary components. Using flux cored filler metal in the root pass may introduce slag inclusion in the root weld layer in contact with the reactor coolant, providing a crack initiation site based on current operating experience.

   c. The staff notes that Table 5.2-1 in Chapter 5 of the AP1000 DCD, Tier 2 should also include ASME Code Filler Metal Specification SFA 5.30 under welding consumables.

Therefore, the NRC staff requests that Westinghouse delete the proposed addition of these materials from the AP1000.or provide further justification addressing the acceptability of the proposed addition of ASME Code Filler Metal Specifications SFA 5.1, 5.17, and 5.22. As currently proposed, the staff finds the proposed addition of the materials does not meet NRC regulations on the basis that the changes

(1) unacceptability decrease the overall safety and reliability of the facility design and (2) contribute to a decreased standardization of the certification information contrary to 10 CFR 52.63(a)(1)(vi) and (vii).

Questions (Revision 1):

1) In Table 5.2-1 of the FSAR, provide a list for each part of the reactor coolant pump (RCP) that will be stainless steel and which will be carbon steel. Otherwise, delete the option to use carbon steel material for the reactor coolant pressure boundary of the RCP.

2) Provide justification and operating experience to use carbon steel as an option for stainless steel reactor coolant pressure boundary parts (i.e., pressure forgings for the reactor coolant pump). In addition, provide justification and operating experience to use carbon steel as an option for low alloy steel reactor coolant pressure boundary parts (i.e., pressure forgings, including nozzles and tubesheets of the steam generator). Otherwise, delete the option to use carbon steel material for the reactor coolant pressure boundary.

3) Your response stated that carbon steel filler metal specifications and the associated base materials are used for welding the stator shell. Discuss the types of welds to be performed on the stator shell, since there appears to be no welding on the stator shell other than the welds joining the stator shell to the stator main flange and the stator lower flange. Include how the stator shell will be welded to the stator main flange and the stator lower flange.

4) What material is the stator can? How is it attached to the pump?

5) Discuss why the stator can and rotor can are not designed as a pressure boundary part since its primary function is to contain the reactor coolant. Discuss which areas of the pump are wetted and non-wetted and how the design (stator can and rotor can) will prevent reactor coolant from contacting the carbon steel portions. Since the motor will stop working if the stator becomes wet, discuss what amount of leakage would be needed to stop the motor and the reliability of the stator can and rotor can.

6) Explain why AP1000 will not use Inconel (Alloy 690) consumable inserts (SFA 5.30) since Inconel (Alloy 690) safe ends will be used for some components (i.e., pressurizer and steam generator).

7) Explain how carbon steel filler metals using flux (SFA 5.1 and 5.17) will be used and for which reactor coolant pressure boundary welds. Otherwise, delete the option to use carbon steel material for the reactor coolant pressure boundary.

8) Proposed Note 4 for Table 5.2-1 only limits use of carbon steel for welds that are not exposed to reactor coolant. Provide justification why this limitation does not apply to base material.

9) Clarify whether proposed Note 3 to Table 5.2-1 implies that this note only applies to gas shielded FCAW electrodes, or that only gas shielded FCAW electrodes with the FCAW process are to be used. In addition, the allowance of using FCAW rod per SFA 5.22 with the GTAW process for welding the root layer should be prohibited. Provide justification and nuclear operating experience for using FCAW on stainless steel reactor coolant pressure boundary material.

10) Table 5.2-1 of the FSAR was changed in Revision 17 to replace material specifications SA-312 and SA-376 for seamless pipe with material specification SA-479 for hot or cold-rolled bar stock. Provide justification and operating experience for using cold-rolled bar stock in lieu of seamless pipe. In addition, the UNS designation S21800 for material specification SA-479 has higher carbon, phosphorus and silicon composition than Types 304 and 316, along with a low chromium content with no molybdenum additions. Discuss how this material is similar to Types 304 and 316 stainless steels, and justify the compatibility with the reactor coolant, along with operating experience. Otherwise, remove the UNS designation S21800 from Table 5.2-1. Which of these materials are used for the Quickloc?

Questions (Revision 2):

1) In response to RAI Rev 1 question 2, Westinghouse's modification to Table 5.2-1 (Sheet 2 of 5) of the DCD did not clarify that the SA-508, CL 1a material is only for the small nozzle pressure forgings on the steam generator. Please clarify this table by listing the "Pressure forgings-small nozzles(5)" with the SA-508, CL1A material specification separately from "Other Pressure Boundary Forgings and Tubesheet" which has the material specification SA-508, GR3, CL2. Also, confirm that DCD paragraph 5.2.3.2.2, which states that carbon steel used in principal pressure-retaining applications which is exposed to reactor coolant will be clad with corrosion resistant cladding, applies to these carbon steel small nozzle forgings.

2) The following is in regards to Westinghouse's response to RAI Rev 1 question 3:

   a. The filler metal classifications, e.g., EH11K, etc., for carbon and low alloy steels should be included in Table 5.2-1, similar to the filler metal classifications listed for stainless steel materials.

   b. Weld filler material specification SFA5.9, classification ER309 is used for the weld buttering on the RCP stator shell, which is subsequently post weld heat treated. Typically, filler material classification ER309L is used when it is exposed to a heat treatment in the sensitization temperature range of 800°F to 1500°F, as discussed in RG 1.44. Therefore, revise Table 5.2-1 to state that ER309L is used when exposed to post weld heat treatment that could sensitize the stainless steel material.

3) The following is in regards to Westinghouse's response to RAI Rev 1 question 4:

   a. Westinghouse stated that the stator can is made of Hastelloy C276 (ASTM B-575, UNS N10276) material. Provide operational experience for this material since it is exposed to the reactor coolant and also prevents the carbon steel pressure boundary parts from being exposed to the reactor coolant.

   b. Westinghouse stated that it could be possible for 2 gallons of water to accumulate in the bottom end of the stator region. If this occurs, will the proposed carbon steel pressure boundary be exposed to reactor coolant? If so, discuss why degradation mechanisms, such as general corrosion, pitting and boric acid corrosion, will not affect the integrity of the carbon steel pressure boundary.

4) Concerning Westinghouse's response to RAI Rev 1 question 6, if consumable inserts are not used for alloy 52 welding of the alloy 690 safe-end, provide the method and weld joint used to ensure complete weld penetration. It should be noted that this weld is the field weld (closure weld) joining the stainless steel piping to the alloy 690 safe-end.

5) Since Westinghouse's response to RAI Rev 1 question 7 states that filler material specification SFA 5.1 is only used for making weld repairs and base material repairs, Table 5.2-1 should be revised accordingly, so that this or any filler material specification that contains flux is not used for welding the root pass of welds.

Questions (Revision 3):

Subsequent to the Revision 2 responses provided by Westinghouse, phone calls between Westinghouse and the NRC were held on April 20 and May 26, 2010, during which the NRC provided verbal comments on the Revision 2 responses. Following the May 26 phone call, the NRC provided three additional comments in an e-mail from Perry Buckberg (NRC) to John DeBlasio (Westinghouse). A draft version of the responses to the above comments were reviewed with the NRC during a meeting/phone call on June 10, 2010. The comments/questions from all of the above are summarized below.

1) Revision 2, Response #4 – For the RAI response to #4 in the April 7, 2010 letter, include a discussion similar to what was discussed on the phone call, that the SG nozzle to the RCP pump casing weld will be performed from both sides since

there is access to both sides to ensure adequate fusion.

2) Notes to Table 5.2-1:

Note 4 – Note 4 should also apply to "Carbon steel pressure boundary welds" under Welding Consumables in Table 5.2-1.

Note 5 – Reword to read "if exposed and not subsequently solution annealed should not contain more than 0.03% carbon."

Note 6 – Include the reason and justification for adding EC (composite) electrode in note 6. Note this was not in response to an RAI, but a Westinghouse proposed change to the DCD. Westinghouse letter dated April 7, 2010, proposed other changes such as using EQ strip electrodes for cladding, but never mentioned EC electrodes. Therefore, provide the use of the EC electrodes and justification that it is similar to and compatible with the other filler metal material and with the reactor coolant, and that the change increases the standardization of the certification information in the DCD in accordance with 10 CFR 52.63(a)(1)(vii) (similar to what was discussed in the phone call on 5/26/2010). Also, discuss whether the use of stranded or metal cored EC electrodes will be used. Discuss whether the metal cored electrode uses a type of flux (coating) and produces slag when welded. If this is the case, this electrode (in the bare electrode specification) should not be used for the root pass or in contact with the reactor coolant.

Note 7 – Does WEC mean "When specified or allowed by ASME Code". Proposed changes to AP1000 DCD, Sections 5.2.3.1 and 6.1.1.2, for consistency with revised note 7 in Table 5.2-1. Also, any other relevant section should be changed to be consistent with the proposed changes.

3) Provide a complete Table 5.2-1 showing all the revisions resulting from this RAI, including required corrections which were identified.

Westinghouse Responses to Revision 0 Questions:

a. The ASME Code Filler Metal Specifications SFA 5.1 and 5.17 and the associated carbon steel base materials (SA-508, Grade 1) are used for welding of the stator shell of the reactor coolant pump. Although part of the pressure boundary, the stator shell is not normally exposed to the reactor coolant because the stator "can" separates the reactor coolant from the stator and the stator shell pressure boundary. The only time the stator shell would be exposed to reactor coolant is if the stator can fails. If this occurs the pump would not longer operate and would have to be replaced/repaired.

A note will be added to Table 5.2-1, as shown in the DCD markup given below, to identify that these weld filler materials will not be exposed to reactor coolant.

In the analysis of a reactor coolant pump flywheel failure, a stainless steel pressure boundary is considered because it is assumed that any flywheel fragments would impact the pressure boundary components immediately adjacent (radially) to the flywheel. These components are the casing, thermal barrier, and stator closure ring for the upper flywheel, and the stator lower flange for the lower flywheel.

b. Westinghouse prohibits the use of flux bearing weld processes for root welds in which the back side is exposed to fluid, unless the backside is first back gouged and back welded. This requirement is included in APP-GW-VLR-010, " AP1000 Supplemental Fabrication and Inspection Requirements" in Section 4.1.2 which states:

   "Welding processes that use flux, such as FCAW, SMAW, or SAW shall not be used on the root pass except for joints welded from two sides where the root is back gouged to sound metal as evidenced by magnetic particle or liquid penetrant testing."

   A note will be added to DCD Table 5.2-1, as shown in the DCD markup given below, to identify this restriction.

c. Westinghouse will include ASME Code Filler Metal Specifications SFA 5.1, 5.17, 5.22, and 5.30 under Welding Consumables in DCD Table 5.2-1 as shown in the DCD markup given below.

Westinghouse Responses to Revision 1 Questions:

1) The stainless, alloy, and carbon steel Class 1components of the reactor coolant pump are listed in the table below.

Pressure Boundary Class 1 Wetted		**Pressure Boundary Class 1 Non-wetted**	
Part	Material	Part	Material
Casing	Stainless steel	Stator main flange	Carbon steel
Upper and lower seal rings (canopy seals)	Stainless steel	Stator shell	Carbon steel
Stator closure ring	Stainless steel	Stator vent flange	Stainless steel
Stator closure	Stainless steel	External heat exchanger supports	Carbon steel
Shell lower flange	Stainless steel	Terminal gland, adapter, adapter nut	Stainless steel
Stator cap	Stainless steel	Stator RTD receptacle	Stainless steel
External heat exchanger primary side	Stainless steel	RTD nut	Stainless steel
External heat exchanger piping & flanges	Stainless steel	Main Flange Stud	Alloy steel
Fill & drain nozzle	Stainless steel	Main Flange Nut	Alloy steel
Bearing water RTD thermowell	Stainless steel	End closure bolt	Alloy steel
Speed sensor well	Stainless steel		
Phase reference sensor well	Stainless steel		
Thrust bearing sleeve	Stainless steel		
Upper basealign ring (for lower radial bearing and upper thrust bearing)	Stainless steel		
Lower base ring (for lower thrust bearing)	Stainless steel		

A note will be added to DCD Table 5.2-1 to indicate which reactor coolant pump pressure boundary components are carbon steel. This note is shown in the markup of Table 5.2-1 in the DCD Revision Section at the end of the responses.

2) Carbon steel is used only for those pressure boundary components which are not normally exposed to the reactor coolant. Carbon steel has a higher yield stress than 304 stainless steel and provides higher margins against nut to main flange bearing stresses. For a 304 stainless steel main flange there is a potential for the main flange stud load to increase significantly at operating conditions due to the relative thermal expansion between the stud and main flange.

   All large canned pumps designed by Curtiss-Wright EMD have carbon steel in the locations of interest.

The only CL 1A pressure forgings on the steam generator are for the small nozzles on the generator – blowdown, sampling, and level tap nozzles. These smaller nozzles are typically from SA-508 CL 1A and do not represent a departure from recent replacement steam generator designs. All of the large, major forgings, such as the tubesheet, upper and lower shells, elliptical head, and transition cone, are SA-508 Gr 3 Cl 2.

DCD Table 5.2-1 will be modified to clarify the steam generator small nozzle and tube sheet materials. The markup of Table 5.2-1 is included in the DCD Revision Section at the end of the responses.

3) The stator shell is welded to the main flange using the submerged arc welding (SAW) process. This joint is full penetration, approximately 4.5" thick and is welded from one side, the outside diameter. Both base materials are SA-508 Grade 1 which is classified as P No. 1 in the ASME code. The weld filler material is per SFA 5.17, classification EH11K. Once this weld is completed the shell/flange is stood upright with the main flange down and several layers of weld buttering are deposited on the end of the shell. This is done using the SAW process and the weld filler material is per SFA 5.9, classification ER309. After the completion of weld buttering, post weld heat treatment is performed. Machining is then performed on the inside and outside diameters of the shell/ flange weld and the buttering is machined in order to provide a weld prep for the shell to lower flange weld. The shell/flange weld is inspected via radiography and magnetic particle testing is performed on the inside and outside diameter surfaces. The buttered and machined weld prep on the shell is liquid penetrant inspected. The lower flange is then welded to the buttered portion of the shell/flange. The lower flange material is per SA-336, Grade F304, classified as P No. 8. The SAW process is used for this weld also and the joint design is essentially the same as for the shell to main flange joint. The weld filler material is per SFA 5.9, classification ER308. Following welding and machining, radiography is performed along with liquid penetrant inspection of both the inside and outside diameter surfaces.

4) The base material for the stator can is Hastelloy C276. (ASTM B-575, UNS N10276). It is welded to portions of the stator pressure boundary that are stainless steel.

5) The primary function of the rotor and stator cans is to retain primary fluid and keep it from contacting electrical windings. The primary function does NOT include keeping primary fluid from escaping to the atmosphere. In addition, the rotor can is not in the load path to the atmosphere.

If the cans were designed as primary pressure boundary parts they would be prohibitively thick and the motor could not function electrically.

The stator windings and laminations and associated structure (end winding supports, core mechanical structure and power terminals) and the rotor laminations and squirrel cage are considered to be the non-wetted portions of the pump. Other parts internal to the pump are considered wetted.

As stated above the rotor can is not in the load path to the atmosphere, and will not be discussed further in this response.

The stator can retains primary fluid. As described above it is welded to portions of the stator pressure boundary that are stainless steel. The can is supported in a radial direction (to resist internal primary fluid pressure) by the stator laminations and a series of short cylinders that bridge the gap between the stator winding and the SST pressure boundary. This pressure force is in the load path that ends at the primary pressure boundary components. The stator can provides a hermetically sealed barrier between the primary fluid and the carbon steel pressure boundary parts.

The motor will stop working if the power terminals become wetted sufficiently to short between 2 of the 3 phase connections. This could happen if approximately 2 gallons of water were to accumulate in the bottom end of the stator region that is normally non-wetted. The motor will operate successfully, of course, if there is no moisture present. It is unknown at exactly what point between those two quantities that the motor might otherwise become wet enough to fail.

There are no known failures of EMD-designed and manufactured canned motors of this general size due to a stator can failure.

6) The code year of construction for the AP1000 is 1999 with 2000 addenda. This year of the code does not have a consumable insert classification for alloy 690 (IN-52). Since Westinghouse sub-contracts the construction of most of the equipment containing reactor coolant, it is the vendor's choice to use consumable inserts or not. Most of the vendors do not choose to use consumable inserts since the primary use of consumable inserts is for manual GTAW, and most safe ends are welded with automatic GTAW. So even if consumable inserts could be added, it is not likely they would be used in lieu of the filler metal already listed.

7) The use of SFA 5.17 weld filler material for reactor coolant pump pressure boundary welds is described in the response to Question 3 above. As for the use of SFA 5.1, the reactor coolant pump vendor is currently qualifying a welding procedure using filler metal classification E7018 to be used for making weld repairs of the shell/main flange joint. This procedure would also be usable for base material repairs on the shell or main flange.

Using welding processes containing flux is only a concern when doing single sided welding where the root of the weld is exposed to reactor coolant. The DCD paragraph 5.2.3.2.2 states that any carbon steel that is exposed to reactor coolant will be clad. So any weld on carbon or low alloy steel will not be exposed to reactor coolant whether the weld was performed with a process using flux or a process that does not use flux.

8) The original intent of adding Note 4 to Table 5.2-1 was to address a previous NRC comment. Since it is basically redundant with regards to paragraph 5.2.3.2.2, Westinghouse recommends that the note be deleted as shown in the markup of Table 5.2-1 which is included in the DCD Revision Section at the end of the responses. DCD paragraph 5.2.3.2.2 states:

   "Ferritic low-alloy and carbon steels used in principal pressure-retaining applications have corrosion-resistant cladding on surfaces exposed to the reactor coolant."

9) The purpose of the note is to limit the use of filler metals listed in SFA-5.22 to only those used for gas shielded FCAW.

   Using GTAW with flux-cored rod is prohibited since the SFA-5.22 filler metals are limited to gas-shielded FCAW applications (see proposed Note 3 of DCD Table 5.2-1 in the Revision 0 response to RAI SRP 5.2.3-CIB1-01). Any GTAW rod would start with an R instead of an E, and as shown in Table 5.2-1 only E rods are permitted.

10) The SA-312 and SA-376 material for seamless pipe changed to SA-479 for hot or cold-rolled bar stock because of the AP1000 design change to incorporate the Quickloc design. On the previous design there were forty-two (42) individual penetrations for the Incore Instrument Thimble Assemblies (IITAs) and with the Quickloc design there are eight (8) Quickloc Instrument Nozzle (QIN) penetrations with up to six (6) IITAs in each for a total of eight (8) QINs. Hot or cold-rolled bar stock has been used in previous Quickloc installations.

   The operating experience for SA-479, S21800 (Nitronic 60) Quickloc pressure boundary parts are as follows:

Table 10-1: Quickloc Plants and Installation Date

Quickloc Plants	Installation Date
Waterford Unit 3	Fall 1995
St. Lucie Unit 2	Spring 1997
St. Lucie Unit 1	Fall 1997
Calvert Cliffs Unit 2	Spring 2001
Calvert Cliffs Unit 1	Spring 2006

   In addition, SA-479, S21800 has been used for Core Exit Nozzle Assembly (CETNA) pressure boundary parts on various plants since the Fall of 1988. CETNAs have been installed on approximately 50 plants (domestic and international).

SA-479 or SA-240 plate Grade S21800 has been used in the construction of a number of parts for reactor vessel internals (RVI) for Combustion Engineering (C-E) NSSS plants. Domestic and international plants which have been in service beginning in the mid-1980's through current plants have utilized this grade of austenitic stainless steel. Table 10-2~~Table 10-2~~ lists the S21800 parts used in the RVI for these plants. The identified items were included in the original specification of the RVI for these units and were fabricated and installed during the original construction of the plants.

Table 10-2: UNS S21800 Parts in Reactor Vessel Internals

Component	Specification
Bushing	SA-479
Upper connector	SA-479
Pin	SA-479 or SA-240
Concave Spherical Washer	SA-479
Convex Spherical Washer	SA-479
Connector	SA-479
Guide Tube	SA-479
Guide Tube Reducer	SA-479
Nose	SA-479

Older C-E NSSS have also utilized S21800 as original parts, such as the instrument guide block and for modifications and repairs. One modification utilized S21800 as part of the reactor level monitoring system (RVLMS) probe guide path. This consisted of welded construction of two S21800 items welded to a Type 304 stainless steel tube. A repair was also made to the thermal shield in on plant, replacing the thermal shield positioning pins that support the thermal shield on the core barrel in the RVI. These pins were hardfaced to provide additional wear resistance of the face of the pin against the core barrel. The pins are threaded and torqued into the thermal shield to provide structural stability between the thermal shield and core barrel.

The S21800 austenitic stainless steel was specified with the same requirements used for Type 304 bar material used in the RVI. Requirements included limits on carbon and cobalt content, corrosion testing in accordance with ASTM A 262 for welded construction of austenitic stainless steels and NDE performed according to Subsection NG requirements for bar. There have been no reported problems are issues with the S21800 material used in any of the above applications, some which have accumulated over 20 years of operating history.

The chemical compositions of Nitronic 60, type 304 stainless steel, and type 316 stainless steel from the material specification SA-479 are provided in Table 10-3~~Table 10-3~~. The SA-479 cold-rolled bar austenitic stainless steels are all solution-annealed, which recrystallizes the grain structure of the steel.

Table 10-3: Chemical Composition of Nitronic 60, Type 304 Stainless Steel, and Type 316 Stainless Steel

Type	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Nitrogen	Molybdenum
Nitronic 60	0.10	7.0-9.0	0.060	0.030	3.5-4.5	16.0-18.0	8.0-9.0	0.08-0.18	…
304	0.08	2.00	0.045	0.030	1.00	18.0-20.0	8.0-10.5	…	…
316	0.08	2.00	0.045	0.030	1.00	16.0-18.0	10.0-14.0	…	2.00-3.00

Nitronic 60 is an austenitic stainless steel, similar to types 304 and 316. The chromium content of Nitronic 60 is comparable to type 316, and therefore has the same general corrosion resistance. The nickel content is comparable to type 304. The additions of silicon and manganese help to prevent wear, galling, and fretting. Molybdenum in type 316 resists pitting corrosion. Because the Nitronic 60 will not be welded, the sensitization concerns from higher carbon content are not applicable.

The minimum yield and tensile strengths of the materials are listed in Table 10-4~~Table 10-4~~. Nitronic 60 has higher yield and tensile strengths than types 304 and 316 stainless steel.

Table 10-4: Minimum Yield and Tensile Strengths of Nitronic 60, Type 304 Stainless Steel, and Type 316 Stainless Steel

Type	Yield Strength	Tensile Strength
Nitronic 60	50	95
304	30	75
316	30	75

Westinghouse Responses to Revision 2 Questions:

1. The small steam generator nozzle forgings included in Table 5.2-1, and which are delineated in Note 5, are all secondary side nozzles which are not exposed to reactor coolant. As such, these nozzles should not be in this table of reactor coolant pressure boundary materials. Westinghouse will remove the small nozzle component from this table and its associated material (SA-508 CL 1A). The markup of Sheet 2 of Table 5.2-1 given in the Revision 2 DCD Markup Section below reflects the deletion of this line from the table.

2. a) The list of carbon and low alloy steel filler metals that are acceptable would get very long to include in Table 5.2-1. Since ASME Section III, Section II part C, and Section IX already govern the mechanical properties of the filler metal that are required, Westinghouse believes that listing specific filler metals in the Table would not add any value to the DCD. Therefore, Westinghouse will add information to Table 5.2-1 Note 8, which will require that mechanical properties be appropriate for the application.

The revision to Note 8 is shown in the markup of Sheet 5 of DCD Table 5.2-1 shown below in the Revision 2 DCD Markup Section.

b) Westinghouse agrees that using sensitized stainless steel for wetted pressure boundary applications is not appropriate, nor permitted per NRC Regulatory Guide 1.44. Westinghouse will address this by adding a note to the Table 5.2-1. This note will clarify the maximum carbon limit for stainless steel welds which will be exposed to high temperature post weld heat treatment. The addition of the new Note 5 is shown in the markup of Sheet 5 of Table 5.2-1 shown below in the Revision 2 DCD Markup Section.

3. a) Very early in the canned motor pump development history (in the 1950's and 1960's) both the rotor can and the stator can were manufactured from alloy 600 (Inconel). The alloy 600 can material was the source of high electrical drag losses. Hastelloy C material was introduced for the stator can to reduce the electrical losses. The AP1000 reactor coolant pump vendor (EMD) performed extensive fatigue testing of both alloy 600 and Hastelloy C can materials. At some point in time, the Haynes company that manufactures Hastelloy alloys discontinued the manufacture of Hastelloy C and EMD was forced to transition to the use of Hastelloy N for stator cans.

   A later application of a canned motor pump required a can material that would be resistant to sea water and Hastelloy C276 was introduced in the 1990's. The chemical and mechanical properties of the Hastelloy C276 material are closer to those of Hastelloy C than Hastelloy N. Hastelloy C276 material per ASTM-B-575 was selected for the AP1000 RCP stator cans due to its resistivity, fatigue properties, and corrosion resistance.

   EMD has over 40 years of experience with various Hastelloy materials for stator cans that have been operated in a nuclear plant environment. Most of this operating experience was on canned motor pumps for U.S. government applications. There is some canned motor pump experience with the Hastelloy C276 material since the 1990's but not in a nuclear plant environment. Please note that EMD is not permitted to disclose any detailed information on canned motor pump operating experience for government products.

   b) The Wound Stator Assembly is an interference fit into the thick walled cylindrical stator shell and flange that forms the primary pressure boundary for the motor. This pressure boundary is completed on both ends of the cylinder with a top closure and bottom closure, which provide attachment surfaces for a thin non-magnetic metal can to be welded circumferentially. The stator can and weldment forms a hermetic seal for the stator winding. The stator can, however, is not considered to be part of the primary fluid pressure boundary, since a can failure would not release primary fluid to the environment. Accordingly, the shell and flange, and associated closure components and terminal feedthroughs, including the main closure with the casing, are designed to be the primary pressure boundary in the event of a can failed condition.

The stator can is designed to retain the primary pressure, and the motions due to operation and thermal transients are analyzed for fatigue and strain acceptability. The can is supported on each end of the wound stator (in the end turn region of the motor winding where there is no stator iron) with back-up sleeves. These sleeves are non-magnetic high strength corrosion resisting alloy steel, and are spaced with controlled gaps. The circumferential gaps provide for controlled strain of the stator can for thermal motion to prevent critical buckling failure. With this design assurance, as long as the can integrity is maintained, the carbon steel components of the primary pressure boundary are not wetted by the primary fluid that is retained by the boundary.

In the event of a can failure, the primary fluid will enter the wound stator cavity region, and be retained by the pressure boundary. The presence of primary fluid will cause negative effects on the motor winding. These effects would be revealed by the motor terminals being electrically shorted. With the terminal connection end placed at the lower region of the motor, water will collect in the 304 SST cavity and be retained. The terminal connections will ultimately become electrically shorted, causing motor shutdown, with no external involvement. Therefore, from a safety related concern, the stator can leak would be retained, and self managed by motor shutdown.

Another concern to be addressed is the wetting of operational windings depending on where the can leak occurs. It is judged that the windings insulation system, including impregnations, is sufficiently robust such that the primary fluid would not impregnate the insulation system to the copper conductors. Winding failure in the presence of fluid is not suspected as the primary cause of failure. Fluid would most likely pass through the winding and collect in the terminal region, and ultimately create an electrical short.

The concern raised regarding carbon steel corrosion due to primary fluid chemistry is mitigated by the can design integrity, and the 304 SST reservoir at the terminal end. The carbon steel primary pressure cylinder wall above the 304 SST portion has the potential for becoming wetted and therefore susceptible to corrosion depending on the axial can leak location. Although possibly wetted from a can leak, the carbon steel portion of the stator shell will not be subject to exposure to standing water, since any leakage will collect in the lower end of the motor cavity where the stator shell is stainless steel as discussed above. The shell cylinder wall thickness is designed with sufficient margin, in accordance with ASME Section III, such that the minimal surface corrosion would not impact the pressure boundary integrity. The wall thickness has a 25% Factor of Safety Margin, such that the wall thickness would have to be reduced by 0.75 inch by corrosion to achieve minimum wall thickness. This is considered very unlikely since the motor should have failed due to an electrical short in advance of extensive corrosion to the carbon steel wall.

4. There are several methods that can be used to achieve full penetration welds on Inconel or stainless steel material. One is open root welding with the back-side of the weld purged with shielding gas, eliminating the oxygen. The other is to back-gouge and re-weld the back side. Either method is currently more common than using consumable inserts in commercial nuclear applications since consumable inserts are generally only used for manual welding and automatic GTAW is the most common process used for these types of welds.

5. Westinghouse agrees that filler material specifications that contain flux should not be used for welding the root pass of welds. Westinghouse will address this requirement through additional information in Note 8 of Table 5.2-1.

   Note 8 of Table 5.2-1 will be revised as shown in the markup of Sheet 5 of Table 5.2-1 shown below in the Revision 2 DCD Markup Section.

In addition to responses to the five Revision 2 questions, additional DCD revisions to be included in this response to address the following:

- Revisons are included to DCD Subsection 5.2.3.1 and Table 5.2-1 (adding Note 7) to allow alternate welding material or processes. These alternates are generally minor variations of the ENiCrFe-7, ERNiCrFe-7A, or ERNiCrFe-7 filler metals intended to improve weldability by reducing hot cracking and ductility dip cracking (DDC), also called microfissuring, and thus increase the overall safety of the welds since not all microfissuring is readily detected.

- Revisions are included in DCD Table 5.2-1 to allow use of strip electrodes (i.e., EQ electrodes) as permitted filler metals for both stainless steel and Ni-Cr-Fe alloys. This strip electrode is commonly used in the cladding process, and has been widely used in the nuclear and other industries for several decades. Using strip electrode does not change the welding processes. Both strip and wire electrodes can be used with the same welding processes, such as submerged arc welding.

- Revisions are included to DCD Subsections 5.2.3.1, 6.1.1.2 and Table 5.2-1 to provide consistency between the DCD text and Table 5.2-1. There were several instances where welding materials were already listed in the DCD by inclusion in Subsection 5.2.3.1 or 6.1.1.2, but omitted from Table 5.2-1. Other times, welding material product forms were listed for one type of material, but the same product form was not listed for another type of material.

The DCD markups of Sections 5.2.3.1 and 6.1.1.2 and Table 5.2-3 are shown below in the Revision 2 DCD Markup Section.

Westinghouse Responses to Revision 3 Questions:

1) The original question related to the NRC comment was regarding the use of consumable inserts. The original NRC comment was "*Explain why AP1000 will not use Inconel (Alloy 690) consumable inserts (SFA 5.30) since Inconel (Alloy 690) safe ends will be used for some components (i.e., pressurizer and steam generator).*" There were several discussions and draft responses related to this comment which resulted in additional draft responses. The Westinghouse response below is intended to address all of the comments and related discussions on this subject and supersedes the Item 4 response in Revision 2 of this RAI response.

   The code year of construction for the AP1000 is 1999 with 2000 addenda. This year of the code does not have a consumable insert classification for alloy 690 (IN-52). Since Westinghouse sub-contracts the construction of most of the equipment containing reactor coolant, it is the vendor's choice to use consumable inserts or not. Most of the vendors do not choose to use consumable inserts since they primarily use automatic GTAW, and addition of filler metal using automatic GTAW is just as easy or easier to control using the automatic wire feeding equipment already in place rather than use consumable inserts. In addition to consumable inserts, there are several methods that can be used to achieve full penetration welds on Inconel or stainless steel material. One is open root welding with the back-side of the weld purged with shielding gas, eliminating the oxygen. The other is to back-gouge and re-weld the back side. An example of this approach is the current design for the RCP to SG weld, which is designed as a double sided weld since there is access to the 2nd side for back-gouging and re-welding.

2) <u>Note 4</u>
   Note 4 will be added to the "Carbon steel pressure boundary welds" under Welding Consumables in DCD Table 5.2-1.

   Note 4 will also be revised to clarify that the weld filler material is also covered in this note. The revised Note 4 will read:
   "GR1 material (carbon steel) and associated filler material is used only for reactor coolant pump components which are not exposed to the reactor coolant. These components are limited to the stator main flange, stator shell, and external heat exchanger supports."

   The revised Note 4 and the additional reference to Note 4 in the table are included in the complete markup of Table 5.2-1 which is provided in the section "Design Control Document (DCD) Revision Associated with Revision 3" below.

   <u>Note 5</u>
   Westinghouse maintains that this requirement actually exceeds the requirements of Regulatory Guide 1.44. In Regulatory Guide 1.44, regulatory position 6 is addressing controlling sensitization of weld heat affected zones. Therefore, the

maximum 0.03% carbon content maximum is for the base metal. In this case, we are discussing the content of the weld metal. ASME SFA specifications permit the maximum carbon contend of low-carbon filler metals to be up to 0.04% maximum, which is higher than most of the low-carbon base metals, for which the ASME SA specifications limit the maximum carbon to 0.03%. So this statement falls into line with nuclear industry practice which has used ASME SFA classified filler metals for quite a long time, and conforms to the regulatory guide since the 0.03% maximum carbon is not addressing weld metal. Additionally, Regulatory Guide 1.44 regulatory position 5 exempts weld metal with a ferrite content of 5 percent of more from any sort of corrosion testing even if exposed to the temperature range of 800F to 1500F. So in this regard, any testing of filler metal exceeds the regulatory guide requirements since ASME Section III automatically requires all filler metal to contain at least 5 FN (equivalent to %), which the AP1000 complies with.

To clarify, Note 5 of Table 5.2-1 will be revised to read:
Austenitic stainless steel filler metals that are exposed to temperatures within the 800°F to 1500°F temperature range after welding and are not subsequently solution annealed do not contain more than 0.03% or 0.04% carbon by weight (depending on the maximum carbon content of the corresponding low-carbon classification in the SFA specification), or have demonstrated non-sensitization per Regulatory Guide 1.44.

This revised Note 5 is included in the complete markup of Table 5.2-1 which is provided in the section "Design Control Document (DCD) Revision Associated with Revision 3" below.

<u>Note 6</u>
Regarding note 6 of the table which permits the use of EC type filler metals: The DCD Rev 17 Table 5.2-1 was not intended to limit the filler metal forms permitted in SFA-5.9, because the design has always allowed other forms. However, since only the most common form is listed (such as ER308L), it could be construed that it was limiting the allowable forms. So other equally valid forms such as EQ and EC were added to the table to clarify this position. First of all, the note is not designated as applicable to Ni-Cr-Fe filler metals in SFA-5.14 because that specification does not have an EC type classification for wire/rod as of this point. So the EC type classification only needs to be applied to SFA-5.9 as listed in the table. Also note that the low-alloy steel and carbon steel filler metal specifications listed in this table, paragraph 6.1.1.2, and 5.2.3.1 already permit composite wires as well. The reason it is desirable to clarify that EC filler metals may be used is that there are several advantages to using EC type filler metals, and some WEC vendors either are, or have proposed using them in production. One advantage for using stranded wire for EC for automatic GTAW is that the stranded wire is more flexible, which aids in wire feeding. When feeding the wire into tight quarters, the more flexible wire can feed more smoothly when the wire conduit makes sharp turns. The lack of cast to the stranded wire after coming off of the spool also keeps the wire more stable at the

point of wire feed. Another advantage that is available for EC type filler metals is metal cored wire used for GMAW. The arc characteristics can have more welder appeal than solid wire, which can lead to more repeatably sound welds. Due to higher current density of the metal-cored wires, they can also be more productive than solid wires due to a higher deposition rate. Specifically listing composite filler metals in the DCD does not decrease standardization because the weld deposit composition of either stranded or metal cored wires must meet the exact same composition requirements as the solid wire in SFA-5.9. The mechanical properties must also meet identical standards. Therefore, there would not be any degradation in corrosion resistance or mechanical performance due to the use of composite wires. The identical composition that cored wires have to the sold wires may be accomplished in cored wires with the same principle used for SMAW welding, where the sheath (or core wire for SMAW) may be made from a similar composition material, but the weld deposit ends up with the correct composition. An example would be when the sheath or core wire could be made from 308L, but metal powder additions to the core (or flux for SMAW) add additional Molybdenum, so that the final composition ends up as 316L. Note that similar to solid wires, composite wires including metal cored wires, do not use a flux such as would be found with SMAW, SAW, or FCAW welding, and can be used in the same locations that GMAW or GTAW with solid wires would be used.

Note 7

Note 7 in DCD Table 5.2-1 and text additions in DCD sections 5.2.3.1 and 6.1.1.2 are intended to allow alternate welding material or processes. These alternates are generally minor variations of the ENiCrFe-7, ERNiCrFe-7A, or ERNiCrFe-7 filler metals intended to improve weldability by reducing hot cracking and ductility dip cracking (DDC), also called microfissuring. The use of these alternates will improve AP1000 weld integrity by allowing the use of filler metals that have improved ductility dip or hot cracking resistance compared to the currently allowed 152/52/52M filler metals.

Note 7 in DCD Table 5.2-1 will be revised to read:
"These materials are UNS N06052, N06054, & W86152, where F43 grouping is allowed by codes cases 2143-1 & 2142-2. Note that UNS N06054 is only in ASME Section II part C 2004 with 2006 addenda and later. Similar welding alloys developed for improved weldability may be used as allowed by ASME B&PV Code rules."

The reference to Note 7 will be moved from its current location in the "Class, Grade, or Type" column to the "Component" column after "Ni-Cr-Fe corrosion resistant cladding, buttering, and welds." This change was made since the note applies to all the materials listed with this component. With the current location of the note after "EQNiCrFe-7A" it could be interpreted to apply only to that one material.

This revised Note 7 and the change to the location of the reference to Note 7 are included in the complete markup of Table 5.2-1 which is provided in the section

"Design Control Document (DCD) Revision Associated with Revision 3" below.

DCD sections 5.2.3.1 and 6.1.1.2 will be revised to include the text similar to the following in order to be consistent with Note 7 in DCD Table 5.2-1: "*similar welding alloys developed for improved weldability as allowed by ASME B&PV Code rules.*"

The revised DCD sections 5.2.3.1 and 6.1.1.2 are provided in the section "Design Control Document (DCD) Revision Associated with Revision 3" below.

3) A complete DCD Table 5.2-1 showing all the revisions resulting from this RAI response is provided in the section "Design Control Document (DCD) Revision Associated with Revision 3" below.

Design Control Document (DCD) Revision Associated with Revision 0 Questions: (These changes superseded by Revision 2 DCD markups which follow these Revision 0 and Revision 1 markups.)

Markup of DCD Table 5.2-1 Sheet 5:

Table 5.2-1 (Sheet 5 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Welding Consumables		
Corrosion resistant cladding, buttering, and welds	SFA 5.4 and 5.9	E308, E308L, E309, E309L, E316, E316L, ER308, ER308L, ER309, ER309L, ER316, ER316L
	SFA 5.11	ENiCrFe-7
	SFA 5.14	ERNiCrFe-7/A
	5.22(3)	E308LTX-Y, E308TX-Y,
		E309LTX-Y, E309TX-Y,
		E316LTX-Y, E316TX-Y
	SFA 5.30	IN308, IN308L, IN316, IN316L
Carbon steel pressure boundary welds(4)	SFA 5.1, 5.17, 5.30	To be compatible with base material
Low alloy pressure boundary welds	SFA 5.5, 5.23, 5.28	To be compatible with base material

__Notes:__
1. Limited to seamless form only
2. Subject to manufacturing sequence and final finish condition review
3. Gas Shielded FCAW electrodes only. These electrodes shall not be used for root passes except for joints welded from two sides where the root is back-gouged to sound metal as evidenced by magnetic particle or liquid penetrant testing.
   X=Position, acceptable values 0 (flat and horizontal) and 1 (all positions)
   Y=Shield Gas, acceptable values 1 (100% CO_2) and 4 (75-80% Argon, remainder CO_2)
4. Limited to applications in which the welds are not exposed to reactor coolant.

Design Control Document (DCD) Revision Associated with Revision 1 Questions: (These changes superseded by Revision 2 DCD markups which follow these Revision 0 and Revision 1 markups.)

In response to the Revision 1 questions, the markups of the DCD Table 5.2-1 Sheets 2, 3, and 5 are given below. The basis for the markup of Sheet 5 is the proposed table in the Revision 0 response. Only the changes on Sheet 5 resulting from the Revision 1 responses are indicated. The markups are in response to Revision 1 Questions 1, 2, and 8.

Table 5.2-1 (Sheet 2 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Steam Generator Components		
Pressure plates	SA-533	Type B, CL 1 or CL 2
Pressure forgings Small nozzles(5) Other Pressure Boundary Forgings and Tubesheet	SA-508 SA-508	CL 1A GR 3, CL 2
Nozzle safe ends	SA-182 SA-336 or SB-564	F316, F316L, F316LN F316LN N06690

Table 5.2-1 (Sheet 3 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Reactor Coolant Pump		
Pressure forgings	SA-182 SA-508 or SA-336	F304, F304L, F304LN, F316, F316L, F316LN GR1(4) F304, F304L, F304LN, F316, F316L, F316LN

Table 5.2-1 (Sheet 5 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Welding Consumables		
Corrosion resistant cladding, buttering, and welds	SFA 5.4 and 5.9	E308, E308L, E309, E309L, E316, E316L, ER308, ER308L, ER309, ER309L, ER316, ER316L
	SFA 5.11	ENiCrFe-7
	SFA 5.14	ERNiCrFe-7/A
	5.22[3]	E308LTX-Y, E308TX-Y, E309LTX-Y, E309TX-Y, E316LTX-Y, E316TX-Y
	SFA 5.30	IN308, IN308L, IN316, IN316L
Carbon steel pressure boundary welds	SFA 5.1, 5.17, 5.30	To be compatible with base material
Low alloy pressure boundary welds	SFA 5.5, 5.23, 5.28	To be compatible with base material

Notes:
1. Limited to seamless form only
2. Subject to manufacturing sequence and final finish condition review
3. Gas Shielded FCAW electrodes only. These electrodes shall not be used for root passes except for joints welded from two sides where the root is back-gouged to sound metal as evidenced by magnetic particle or liquid penetrant testing.
   X=Position, acceptable values 0 (flat and horizontal) and 1 (all positions)
   Y=Shield Gas, acceptable values 1 (100% CO_2) and 4 (75-80% Argon, remainder CO_2)
4. GR1 material (carbon steel) is used only for reactor coolant pump components which are not exposed to the reactor coolant. These components are limited to the stator main flange, stator shell, and external heat exchanger supports.
5. The small steam generator nozzles are limited to the blowdown, sampling, and level tap nozzles.

Design Control Document (DCD) Revision Associated with Revision 2: (These changes superseded by Revision 3 DCD markups which follow these Revision 0, Revision 1, and Revision 2 markups.)

The Revision 2 markups of the DCD Revision 17 are provided below. These markups are a composite that supersede or include the revisions identified in Revision 0 and Revision 1 responses provided above.

Markup of DCD Subsection 5.2.3.1, first, third and fifth paragraphs:

Table 5.2-1 lists material specifications used for the principal pressure-retaining applications in Class 1 primary components and reactor coolant system piping. Material specifications with grades, classes or types are included for the reactor vessel components, steam generator components, reactor coolant pump, pressurizer, core makeup tank, and the passive residual heat removal heat exchanger. Table 5.2-1 lists the application of nickel-chromium-iron alloys in the reactor coolant pressure boundary. The use of nickel-chromium-iron alloy in the reactor coolant pressure boundary is limited to Alloy 690, or its associated weld metals Alloys 52, 52M, 152, and similar alloys developed for improved weldability. Steam generator tubes use Alloy 690 in the thermally treated form. Nickel-chromium-iron alloys are used where corrosion resistance of the alloy is an important consideration and where the use of nickel-chromium-iron alloy is the choice because of the coefficient of thermal expansion. Subsection 5.4.3 defines reactor coolant piping. See subsection 4.5.2 for material specifications used for the core support structures and reactor internals. See appropriate sections for internals of other components. Engineered safeguards features materials are included in subsection 6.1.1. The nonsafety-related portion of the chemical and volume control system inside containment in contact with reactor coolant is constructed of or clad with corrosion resistant material such as Type 304 or Type 316 stainless steel or material with equivalent corrosion resistance. The materials are compatible with the reactor coolant. The nonsafety-related portion of the chemical and volume control system is not required to conform to the process requirements outlined below.

The welding materials used for joining the ferritic base materials of the reactor coolant pressure boundary conform to or are equivalent to ASME Material Specifications SFA 5.1, 5.5, 5.17, 5.18, 5.20, 5.23, 5.28, 5.29, and 5.30. They are qualified to the requirements of the ASME Code, Section III.

The welding materials used for joining nickel-chromium-iron alloy in similar base material combination and in dissimilar ferritic or austenitic base material combination conform to or are equivalent to ASME Material Specifications SFA 5.11 and 5.14. They are qualified to the requirements of the ASME Code, Section III.

Markup of DCD Table 5.2-1 Sheets 2, 3, and 5 (includes responses to Revision 2 questions 1, 2, and 5):

Table 5.2-1 (Sheet 2 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Steam Generator Components		
Pressure forgings (including primary side nozzles and tubesheet)	SA-508	GR 3, CL 2

Table 5.2-1 (Sheet 3 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Reactor Coolant Pump		
Pressure forgings	SA-182 SA-508 or SA-336	F304, F304L, F304LN, F316, F316L, F316LN GR1[(4)] F304, F304L, F304LN, F316, F316L, F316LN

Table 5.2-1 (Sheet 5 of 5)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Welding Consumables		
Austinetic stainless stee corrosion resistant cladding, buttering, and welds	SFA 5.4 SFA 5.9 (6) SFA 5.22(3) SFA 5.30	E308, E308L, E309, E309L, E316, E316L ER308, ER308L, ER309, ER309L, ER316, ER316L, EQ308L, EQ309L E308LTX-X, E308TX-X, E309LTX-X, E309TX-X, E316LTX-X, E316TX-X IN308, IN308L, IN316, IN316L
NI-Cr-Fe corrosion resistant cladding, buttering, and welds	SFA 5.11 SFA 5.14	ENiCrFe-7 ERNiCrFe-7, ENiCrFe-7A, EQNiCrFe-7, EQiCrFe-7A(7)
Carbon steel pressure boundary welds(8)	SFA 5.1, 5.17, 5.18, 5.20, 5.30	To be compatible with base material
Low alloy pressure boundary welds(8)	SFA 5.5, 5.23, 5.28, 5.29	To be compatible with base material

Notes:

1. Limited to seamless form only
2. Subject to manufacturing sequence and final finish condition review
3. Only gas shielded electrodes for use with the FCAW process are permitted. These electrodes shall not be used for root passes except for joints welded from two sides where the root is back-gouged to sound metal as evidenced by magnetic particle or liquid penetrant testing.
   X=Position, acceptable values 0 (flat and horizontal) and 1 (all positions)
   Y=Shield Gas, acceptable values 1 (100% CO_2) and 4 (75-80% Argon, remainder CO_2)
4. GR1 material (carbon steel) is used only for reactor coolant pump components which are not exposed to the reactor coolant. These components are limited to the stator main flange, stator shell, and external heat exchanger supports.
5. Austenitic stainless welds that are exposed to temperatures within the 800°F to 1500°F temperature range after welding and are not subsequently solution annealed do not contain more than 0.04% carbon by weight, or have demonstrated non-sensitization per Regulatory Guide 1.44.
6. In addition to ER, EC (composite) rod/electrodes may also be used.
7. These materials are UNS N06052, N06054, & W86152, where F43 grouping is allowed by codes cases 2143-1 & 2142-2. Note that UNS N06054 is only in ASME Section II part C 2004 with 2006 addenda and

later. Similar welding alloys developed for improved weldability may be used as well.

8. These weld metals are compatible with the base metal mechanical requirements and meet applicable ASME Section III, Section II part C, and Section IX requirements. Their use is limited to applications in which the welds are not exposed to reactor coolant. These weld metals used with a flux bearing welding process are also not used for root passes of single sided welds.

Markup of DCD Table 5.2-3:

Table 5.2-3

ASME CODE CASES

Code Case Number	Title
N-474-2	Design Stress Intensities and Yield Strength Values for UNS06690 With a Minimum Yield Strength of 35 ksi, Class 1 Components, Section III, Division 1
2142-2	F-Number Grouping for Ni-Cr-Fe Filler Metals, Section IX (Applicable to all Sections, including Section III, Division I, and Section XI)
2143-1	F-Number Grouping for Ni-Cr-Fe, Classification UNS W86152 Welding Electrode, Section IX

Markup of DCD Subsection 6.1.1.2, first two paragraphs:

6.1.1.2 Fabrication Requirements

The welding materials used for joining the ferritic base materials of the pressure-retaining portions of the engineered safety features conform to, or are equivalent to, ASME Material Specifications SFA 5.1, 5.5, 5.17, 5.18, 5.20, 5.23, 5.28, 5.29, and 5.30. The welding materials used for joining nickel-chromium-iron alloy in similar base material combination, and in dissimilar ferritic or austenitic base material combination, conform to or are similar to ASME Material Specifications SFA 5.11 and 5.14.

The welding materials used for joining the austenitic stainless steel base materials for the pressure-retaining portions of engineered safety features conform to, or are equivalent to, ASME Material Specifications SFA 5.4, 5.9, 5.22, and 5.30. These materials are qualified to the requirements of the ASME Code, Section III and Section IX, and are used in procedures qualified to these same rules. The methods used to control delta ferrite content in austenitic stainless steel weldments in engineered safety features components are the same as those for ASME Code Class 1 components, described in subsection 5.2.3.4.

Design Control Document (DCD) Revision Associated with Revision 3:

The Revision 3 markups of the DCD Revision 17 are provided below. These markups are a composite that supersede or include the revisions identified in Revisions 0, 1, and 2 responses provided above.

Markup of DCD Subsection 5.2.3.1, first, third and fifth paragraphs:

Table 5.2-1 lists material specifications used for the principal pressure-retaining applications in Class 1 primary components and reactor coolant system piping. Material specifications with grades, classes or types are included for the reactor vessel components, steam generator components, reactor coolant pump, pressurizer, core makeup tank, and the passive residual heat removal heat exchanger. Table 5.2-1 lists the application of nickel-chromium-iron alloys in the reactor coolant pressure boundary. The use of nickel-chromium-iron alloy in the reactor coolant pressure boundary is limited to Alloy 690, or its associated weld metals Alloys 52, 52M, 152, and similar alloys developed for improved weldability as allowed by ASME B&PV Code Rules. Steam generator tubes use Alloy 690 in the thermally treated form. Nickel-chromium-iron alloys are used where corrosion resistance of the alloy is an important consideration and where the use of nickel-chromium-iron alloy is the choice because of the coefficient of thermal expansion. Subsection 5.4.3 defines reactor coolant piping. See subsection 4.5.2 for material specifications used for the core support structures and reactor internals. See appropriate sections for internals of other components. Engineered safeguards features materials are included in subsection 6.1.1. The nonsafety-related portion of the chemical and volume control system inside containment in contact with reactor coolant is constructed of or clad with corrosion resistant material such as Type 304 or Type 316 stainless steel or material with equivalent corrosion resistance. The materials are compatible with the reactor coolant. The nonsafety-related portion of the chemical and volume control system is not required to conform to the process requirements outlined below.

The welding materials used for joining the ferritic base materials of the reactor coolant pressure boundary conform to or are equivalent to ASME Material Specifications SFA 5.1, 5.5, 5.17, 5.18, 5.20, 5.23, 5.28, 5.29, and 5.30. They are qualified to the requirements of the ASME Code, Section III.

The welding materials used for joining nickel-chromium-iron alloy in similar base material combination and in dissimilar ferritic or austenitic base material combination conform to ASME Material Specifications SFA 5.11 and 5.14 or are similar welding alloys to those in SFA-5.11 or SFA-5.14 developed for improved weldability as allowed by the ASME B&PV code rules.. They are qualified to the requirements of the ASME Code, Section III.

Markup of DCD Table 5.2-1:

Table 5.2-1 (Sheet 1 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Reactor Vessel Components		
Head plates (other than core region)	SA-533 or SA-508	Type B, CL 1 or GR 3 CL 1
Shell courses	SA-508	GR 3 CL 1
Shell, flange, and nozzle forgings	SA-508	GR 3 CL 1
Nozzle safe ends	SA-182	F316, F316L, F316LN
Appurtenances to the control rod drive mechanism (CRDM)	SB-167 SB-166 or SA-182	N06690 N06690 or F304, F304L, F304LN, F316, F316L, F316LN
Instrumentation nozzles, upper head	SB-167 SB-166 and SA-182, or SA-479	N06690 N06690 and F304, F304L, F304LN, F316, F316L, F316LN 304, 304L, 304LN 316, 316L, 316LN, S21800
Closure studs	SA-540	GR B23 CL 3 or GR B24 CL 3
Monitor tubes	SA-312(1) or SA-376 or SA-182	TP304, TP304L, TP304LN, TP316, TP316L, TP316LN TP304, TP304LN, TP316, TP316LN F304, F304L, F304LN, F316, F316L, F316LN

Table 5.2-1 (Sheet 2 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Vent pipe	SB-166 SB-167 or SA-312[(1)] SA-376	N06690 N06690 TP304, TP304L, TP304LN, TP316, TP316L, TP316LN TP304, TP304LN, TP316, TP316LN
Steam Generator Components		
Pressure plates	SA-533	Type B, CL 1 or CL 2
Pressure forgings (including primary side nozzles and tube sheet)	SA-508	GR 3, CL 2
Nozzle safe ends	SA-182 SA-336 or SB-564	F316, F316L, F316LN F316LN N06690
Channel heads	SA-508	GR 3, CL 2
Tubes	SB-163	N06690
Manway studs/ Nuts	SA-193 SA-194	GR B7 GR 7
Pressurizer Components		
Pressure plates	SA-533	Type B, CL 1
Pressure forgings	SA-508	GR 3, CL 2
Nozzle safe ends	SA-182 SA-338 or SB-163	F316, F316L, F316LN F316, F316L, F316LN N06690
Manway studs/ Nuts	SA-193 SA-194	GR B7 GR 7

Table 5.2-1 (Sheet 3 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Reactor Coolant Pump		
Pressure forgings	SA-182 SA-508 or SA-336	F304, F304L, F304LN, F316, F316L, F316LN GR1(4) F304, F304L, F304LN, F316, F316L, F316LN
Pressure casting	SA-351	CF3A or CF8A
Tube and pipe	SA-213 SA-376 or SA-312(1)	TP304, TP304L, TP304LN, TP316, TP316L, TP316LN TP304, TP304LN, TP316, TP316LN TP304, TP304L, TP304LN, TP316, TP316L, TP316LN
Pressure plates	SA-240	304, 304L, 304LN, 316, 316L, 316LN
Closure bolting	SA-193 or SA-540	GR B7 or GR B24, CL 2 & CL 4, or GR B23, CL2, CL 3 & 4
Reactor Coolant Piping		
Reactor coolant pipe	SA-376 SA-182(2)	TP304, TP304LN, TP316, TP316LN F304, F304L, F304LN, F316, F316L, F316LN
Reactor coolant fittings, branch nozzles	SA-376 SA-182	TP304, TP304LN, TP316, TP316LN F304, F304L, 304LN, F316, F316L, F316LN
Surge line	SA-376 or SA-312(1)	TP304, TP304LN, TP316, TP316LN TP304, TP304L, TP304LN, TP316, TP316L, TP316LN

Table 5.2-1 (Sheet 4 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
RCP piping other than loop and surge line	SA-312[(1)] and SA-376	TP304, TP304L, TP304LN, TP316, TP316L, TP316LN TP304, TP304L, TP304LN, TP316, TP316L, TP316LN
CRDM		
Latch housing	SA-336	F304, F304L, F304LN, F316, F316L, F316LN
Rod travel housing	SA-336	F304, F304L, F304LN, F316, F316L, F316LN
Valves		
Bodies	SA-182 or SA-351	F304, F304L, F304LN, F316, F316L, F316LN or CF3A, CF3M, CF8
Bonnets	SA-182 SA-240 or SA-351	F304, F304L, F304LN, F316, F316L, F316LN, 304, 304L, 304LN, 316, 316L, 316LN or CF3A, CF3M, CF8
Discs	SA-182 SA-564 or SA-351	F304, F304L, F304LN, F316, F316L, F316LN Type 630 (H1100 or H1150), or CF3A, CF3M, CF8
Stems	SA-479 SA-564 or SB-637	316, 316LN or XM-19 Type 630 (H1100 or H1150) Alloy N07718
Pressure retaining bolting	SA-453 SA-564 SA-193	GR 660 Type 630 (H1100) GR B8

Table 5.2-1 (Sheet 5 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Pressure retaining nuts	SA-453 or SA-194	GR 660 or GR 6 or 8
Core Makeup Tank		
Pressure plates	SA-533 or SA-240	Type B, CL 1 or 304, 304L, 304LN, 316, 316L, 316LN
Pressure forgings	SA-508 or SA-182 SA-336	GR 3 CL 1 or F304, F304L, F316, F316L F304, F304L, F316, F316L
Passive Residual Heat Removal Heat Exchanger		
Pressure plates	SA-533 or SA-240	Type B CL1 or 304, 304L, 304LN
Pressure forgings	SA-508 or SA-336	GR 3 CL 2 or F304, F304L, F304LN
Tubing	SB-163	N06690

Table 5.2-1 (Sheet 6 of 6)

REACTOR COOLANT PRESSURE BOUNDARY MATERIALS SPECIFICATIONS

Component	Material	Class, Grade, or Type
Welding Consumables		
Austenitic stainless steel corrosion resistant cladding, buttering, and welds(5)	SFA 5.4	E308, E308L, E309, E309L, E316, E316L
	SFA 5.9 (6)	ER308, ER308L, ER309, ER309L, ER316, ER316L, EQ308L, EQ309L
	SFA 5.22(3)	E308LTX-Y, E308TX-Y, E309LTX-Y, E309TX-Y, E316LTX-Y, E316TX-Y
	SFA 5.30	IN308, IN308L, IN316, IN316L
Ni-Cr-Fe corrosion resistant cladding, buttering, and welds(7)	SFA 5.11	ENiCrFe-7
	SFA 5.14	ERNiCrFe-7, ERNiCrFe-7A, EQNiCrFe-7, EQNiCrFe-7A
Carbon steel pressure boundary welds(8) (4)	SFA 5.1, 5.17, 5.18, 5.20, 5.30	To be compatible with base material
Low alloy pressure boundary welds(8)	SFA 5.5, 5.23, 5.28, 5.29	To be compatible with base material

Notes:

1. Limited to seamless form only
2. Subject to manufacturing sequence and final finish condition review
3. Only gas shielded electrodes for use with the FCAW process are permitted. These electrodes shall not be used for root passes except for joints welded from two sides where the root is back-gouged to sound metal as evidenced by magnetic particle or liquid penetrant testing.
   X=Position, acceptable values 0 (flat and horizontal) and 1 (all positions)
   Y=Shield Gas, acceptable values 1 (100% CO_2) and 4 (75-80% Argon, remainder CO_2)
4. GR1 material (carbon steel) and associated filler material is used only for reactor coolant pump components which are not exposed to the reactor coolant. These components are limited to the stator main flange, stator shell, and external heat exchanger supports.
5. Austenitic stainless steel filler metals that are exposed to temperatures within the 800°F to 1500°F temperature range after welding and are not subsequently solution annealed do not contain more than 0.03% or 0.04% carbon by weight (depending on the maximum carbon content of the corresponding low-carbon classification in the SFA specification), or have demonstrated non-sensitization per Regulatory Guide 1.44.
6. In addition to ER, EC (composite) rod/electrodes may also be used.
7. These materials are UNS N06052, N06054, & W86152, where F43 grouping is allowed by codes cases 2143-1 & 2142-2. Note that UNS N06054 is only in ASME Section II part C 2004 with 2006 addenda and later. Similar welding alloys developed for improved weldability may be used as allowed by ASME B&PV Code rules.

8. These weld metals are compatible with the base metal mechanical requirements and meet applicable ASME Section III, Section II part C, and Section IX requirements. Their use is limited to applications in which the welds are not exposed to reactor coolant. These weld metals used with a flux bearing welding process are also not used for root passes of single sided welds.

Markup of DCD Table 5.2-3:

Table 5.2-3

ASME CODE CASES

Code Case Number	**Title**
N-474-2	Design Stress Intensities and Yield Strength Values for UNS06690 With a Minimum Yield Strength of 35 ksi, Class 1 Components, Section III, Division 1
2142-2	F-Number Grouping for Ni-Cr-Fe Filler Metals, Section IX (Applicable to all Sections, including Section III, Division I, and Section XI)
2143-1	F-Number Grouping for Ni-Cr-Fe, Classification UNS W86152 Welding Electrode, Section IX

Markup of DCD Subsection 6.1.1.2, first two paragraphs:

6.1.1.2 Fabrication Requirements

The welding materials used for joining the ferritic base materials of the pressure-retaining portions of the engineered safety features conform to, or are equivalent to, ASME Material Specifications SFA 5.1, 5.5, 5.17, 5.18, 5.20, 5.23, 5.28, 5.29, and 5.30. The welding materials used for joining nickel-chromium-iron alloy in similar base material combination, and in dissimilar ferritic or austenitic base material combination, conform to ASME Material Specifications SFA 5.11 and 5.14, or are similar welding alloys to those in SFA-5.11 or SFA-5.14 developed for improved weldability as allowed by the ASME B&PV Code rules.

The welding materials used for joining the austenitic stainless steel base materials for the pressure-retaining portions of engineered safety features conform to, or are equivalent to, ASME Material Specifications SFA 5.4, 5.9, 5.22, and 5.30. These materials are qualified to the requirements of the ASME Code, Section III and Section IX, and are used in procedures qualified to these same rules. The methods used to control delta ferrite content in austenitic stainless steel weldments in engineered safety features components are the same as those for ASME Code Class 1 components, described in subsection 5.2.3.4.

PRA Revision: None.

Technical Report (TR) Revision: None.