Response to

Request for Additional Information No. 50 (927,928) Revision 0

8/21/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 04.05.02 - Reactor Internal and Core Support Structure Materials
Application Section: FSAR Ch 4
CIB1 Branch

Question 04.05.02-1:

Table 4.5-2 of the U.S. EPR FSAR, Tier 2 provides the materials to be used for the reactor vessel internals.

a) Table 4.5-2 of the U.S. EPR FSAR, Tier 2 includes the reactor vessel internals weld Type 304L, per weld material specification SFA5.4, 5.9 or 5.22. Clarify what type of weld material is Type 304L or whether this is a typographical error, since it is not listed in the aforementioned weld material specifications.

b) Provide the material specification for the "Cobalt Alloy" specified in Table 4.5-2 of the U.S. EPR FSAR, Tier 2 for the Upper Internals Assembly and the heavy reflector. In addition, discuss how this alloy will be used (i.e., components, location, design) in the upper internals assembly and in the heavy reflector along with any operating experience with this alloy.

Response to Question 04.05.02-1:

a) Type 304L will be deleted from the weld material section of U.S. EPR FSAR, Tier 2, Table 4.5-2.

b) The cobalt alloy used in the upper internals assembly, as shown in U.S. EPR FSAR, Tier 2, Table 4.5-2, is Stellite 6 or equivalent, which is used for hard facing the Radial Key Inserts, Upper Core Plate (UCP) Guide Pins and Inserts. Stellite 6 is available as welding wire (ASME SFA 5.21 Classification ERCCoCr-A), rod (ASME SFA 5.21 Classification ERCoCr-A), and electrodes (ASME SFA 5.13 Classification ECoCr-A) for deposition onto the base metal.

   Stellite 6 is used in operating pressurized water reactors for components such as CRDM applications, valves, and sliding applications in the RPV internals to minimize wear and degradation.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 4.5-2, Section 4.5.2.1 and Section 4.5.2.5 will be revised as described in the response and indicated on the enclosed markup.

Question 04.05.02-2:

Section 4.5.2.2 of the U.S. EPR FSAR, Tier 2 states that when Section 5.2.3 of the U.S. EPR FSAR is applied to the welding of reactor vessel internals and core support materials, the ASME Code, Section III applies in accordance with GDC 1 and 10 CFR 50.55a. Clarify this statement in order to facilitate which reactor vessel internal components and core support components will be fabricated using the ASME Code.

Response to Question 04.05.02-2:

The reactor vessel internal components are classified as either “Core Support” or “Internal Structures” in Table 3.9.5-1 of the U.S. EPR FSAR, Tier 2. The components classified as “Core Support” are in accordance with ASME Code, Section III, Subsection NG. As stated in U.S. EPR FSAR, Tier 2 Section 3.9.5.2, the components classified as “Internal Structures” are designed and constructed such that they do not adversely affect the integrity of the core support structures in accordance with ASME Code, Section III, Subsection NG-1122(c).

FSAR Impact:

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

Question 04.05.02-3:

Section 4.5.2.1 of the U.S. EPR FSAR, Tier 2 states, "There are no other materials used in the reactor internals or core support structures that are not otherwise allowed under ASME Code, Section III, Subsection NG-2120."

a) Explain this statement with respect to whether Table 4.5-2 of the U.S. EPR FSAR, Tier 2 includes all materials and their corresponding material specifications that will be used for the reactor vessel internals and core supports. If Table 4.5-2 of the U.S. EPR FSAR, Tier 2 does not list all materials used, provide all of the material specifications, and their intended use for the corresponding component.

b) Will Alloy 600 and/or Alloy 82/182 be used for the reactor vessel core supports or reactor vessel internals? If this material is used, discuss how the use of this material will not degrade the component such that the component integrity and function is lost due to PWSCC as seen in current operating experience.

c) Discuss the extent to which Alloy 690 and Alloy 52/52M/152 will be used for reactor vessel core supports and reactor vessel internals?

Response to Question 04.05.02-3:

a) U.S. EPR FSAR, Tier 2 Table 4.5-2 of the U.S. EPR FSAR lists those materials used for fabrication of the RPV internals. Additionally, Alloy 690 is used to fabricate the radial key inserts, washers and locking bars that are attached to the radial keys. Alloy X-750 is used to fabricate the springs installed inside the irradiation specimen capsule access plugs. Austenitic stainless steel Type 304N is used to fabricate the heavy reflector slabs. These materials will be added to this table.

b) No Alloy 600 base metals or Alloy 82/182 weld metals are used in the design of the U.S. EPR reactor vessel core supports or reactor vessel internals.

c) As stated above, Alloy 690 is used to fabricate the radial key inserts, washers and locking bars that are attached to the radial keys. The radial key inserts are classified as “Core Support” in U.S. EPR FSAR, Tier 2 Table 3.9.5-1. Alloy 52/52M/152 is not used for any structural welds for the reactor vessel core supports and reactor vessel internals.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Table 4.5-2 will be revised as described in the response and indicated on the enclosed markup.

Question 04.05.02-4:

Table 4.5-2 of the U.S. EPR FSAR, Tier 2 provides material specifications used for the heavy reflector, and Section 4.3.2.1 of the U.S. EPR FSAR, Tier 2 provides a description of the heavy reflector and states that it replaces the thin baffle plates used in existing reactors.

a) Will the heavy reflector experience a fluence of $5x10^{20}$ n/cm^2 (E>1.0 MeV) or greater in the proposed 60-year life of the U.S. EPR, thereby making the heavy reflector susceptible to IASCC? Discuss how the heavy reflector will not lose its safety function or create loss parts that could affect safety related components and the safe shutdown of the reactor as required by GDC 1 of 10 CFR Part 50 and as discussed in SRP Section 4.5.2. Will the void swelling also affect the integrity of the heavy reflector during the life of the reactor?

b) The heavy reflectors have keyways in the reflector slabs to accommodate the vertical keys. Discuss how keyways and vertical keys are machined (i.e., radii of corners of keyways and keys, etc.) to prevent notches that can act as stress concentrations and crack initiation sites, thereby leading to the loss of function of the heavy reflector.

c) Section 4.3.2.1 states that the heavy reflector consists of stacked forged slabs (rings) positioned on above the other, and uses vertical keys to align the slabs, and axially restrain the slabs by tie rods bolted to the lower core support plate.

   - Provide in the FSAR a detailed drawing of the heavy reflector and its components, along with the corresponding material used for these components.
   - Table 3.9.5-1 lists upper core plate guide pins, centering pins, normal and centering rings, and positioning keys, but are not described in the FSAR section or applicable drawings. Provide in the FSAR the material, location, and function of these components.
   - Tie rods are listed as internal structures, but axially restrain the heavy reflector slabs, thereby providing structural support for the heavy reflector, which is a core support structure. Discuss in detail the function of the tie rods and whether the tie rods provide a core support function by maintaining the integrity of the heavy reflector, which is a core support structure. In addition, discuss how stress relaxation or loss of preload will not degrade the component such that the component (heavy reflector) will not satisfactorily perform its intended safety function as required by GDC 1 of 10 CRF Part 50.

Response to Question 04.05.02-4:

A response to this question will be provided by November 26, 2008.

Question 04.05.02-5:

Will tools used in abrasive work on austenitic stainless steels surfaces be controlled per the requirements in RG 1.37, similar to Section 4.5.1.2.1 of the U.S. EPR FSAR, Tier 2, to prevent the introduction of containments that may promote SSC in accordance with GDC 14? Is so, include this guidance in Section 4.5.2 of the U.S. EPR FSAR, Tier 2.

Response to Question 04.05.02-5:

U.S. EPR FSAR Tier 2 Section 4.5.1.2.1 states: “Tools used in abrasive work on austenitic stainless steel surfaces are controlled per the requirements in RG 1.37 to prevent the introduction of contaminants that may promote stress corrosion cracking in accordance with GDC 14.” In addition, this statement will be added to U.S. EPR FSAR Tier 2 Section 4.5.2.4.

FSAR Impact:

U.S. EPR FSAR, Tier 2, Section 4.5.2.4 will be revised as described in the response and indicated on the enclosed markup.

Question 04.05.02-6:

Table 4.5-2 of the U.S. EPR FSAR, Tier 2 provides the material for the lower internals, and Section 3.9.5.1.2.5 of the U.S. EPR FSAR, Tier 2 describes that the lower internals are centered within the reactor pressure vessel by radial key that are welded to and integral with the reactor pressure vessel.

a) Describe in the FSAR the material used for the radial key inserts, and how the radial key inserts are welded (material, welding process, joint design, etc.) to the RPV.

b) After welding the radial key inserts to the low alloy steel RPV, will the RPV be heat treated? If the RPV is heat treated, discuss how it will affect the radial key inserts and its weld (i.e., sensitization of stainless steel, etc.).

c) If the radial key inserts are subjected to a fluence of $5x10^{20}$ n/cm^2 (E>1.0 MeV) or greater in the proposed 60-year life of the U.S. EPR, thereby making the radial key inserts susceptible to IASCC, discuss how the radial key inserts that support the core will not degrade the component such that the component will not satisfactorily perform its intended safety function as required by GDC 1 of 10 CRF Part 50.

Response to Question 04.05.02-6:

A response to this question will be provided by November 26, 2008.

Question 04.05.02-7:

Is the core barrel weld in the vicinity of the core, and will it be subjected to a fluence of $5x10^{20}$ n/cm^2 (E>1.0 MeV) or greater in the proposed 60-year life of the U.S. EPR, thereby making the core barrel susceptible to IASCC? Discuss design considerations for the core barrel to ensure that any degradation will not impact other safety-related RPV components and cause it to lose its intended safety function as required by GDC 1 of 10 CRF Part 50.

Response to Question 04.05.02-7:

A response to this question will be provided by November 26, 2008.

Question 04.05.02-8:

Section 3.9.5.1.3.4 of the U.S. EPR FSAR, Tier 2 states that the columns are bolted to the upper support plate. Discuss design considerations taken to account for bolt stress relaxation or loss of preload such that the integrity of the bolted components and their intended safety function are not adversely affected as required by GDC 1 of 10 CFR Part 50.

Response to Question 04.05.02-8:

The stress analyses of the bolted joints will take into account the preload relaxation of the fasteners. This will ensure sufficient initial preloads are applied to the fasteners so that adequate final preloads exist to axially restrain the Upper Core Plate to the Upper Support Plate.

FSAR Impact:

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

U.S. EPR Final Safety Analysis Report Markups

4.5.2.1 Materials Specifications

04.05.02-1

The major components for the reactor internals are fabricated from austenitic stainless steel except for the hold-down spring, which is made from martensitic stainless steel and pins and inserts which are coated with Stellite 6 or equivalent which is a cobalt alloy. The materials specifications for the reactor internals and core support materials including weld filler materials are listed in Table 4.5-2—Reactor Vessel Internal Materials, which includes the use of ASME Code Case N-60-5 which is listed as an acceptable code case under RG 1.84. There are no other materials used in the reactor internals or core support structures that are not otherwise allowed under ASME Code, Section III, Subsection NG-2120 (Reference 4). Reactor internals and core support structure weld filler materials are specified in ASME BPV Code, Section II (Reference 2) which is in accordance with GDC 1 and 10 CFR 50.55(a).

4.5.2.2 Controls on Welding

The controls on welding of austenitic stainless steel pressure boundary components provided in Section 5.2.3 apply to the welding of reactor internals and core support components. When Section 5.2.3 is applied to the reactor internals and core support materials, ASME BPV Code, Section III (Reference 4) applies as in accordance with GDC 1 and 10 CFR 50.55(a).

4.5.2.3 Nondestructive Examination

Nondestructive examination (NDE) of base materials is in accordance with ASME Code Section III, Division I, NG-2500 (Reference 4). The NDE methods and acceptance criteria for welds are in accordance with the requirements of the ASME Code Section III, Division 1, NG-5000 (Reference 4) and GDC 1 and 10 CFR 50.55(a).

4.5.2.4 Fabrication and Processing of Austenitic Stainless Steel Components

The details provided in Section 5.2.3 concerning the processing, inspections, and tests on unstabilized austenitic stainless steel components to minimize susceptibility to intergranular corrosion caused by sensitization are applicable to the austenitic stainless steel materials used in the reactor internals and core support structures. Section 5.2.3 verifies compliance of reactor internals and core support structures with RG 1.44. The reactor internals and core support structures are fabricated from low carbon austenitic stainless steels which are heat treated in accordance with RG 1.44 to minimize their susceptibility to stress corrosion cracking. Cold-worked Type 316 austenitic stainless steel used in reactor internals support pins and bolting have a maximum specified room temperature yield strength of 90,000 psi ~~(620 MPa)~~ as determined by the 0.2 percent offset method.

The information provided in Section 5.2.3 is applicable to the reactor internals and core support structures and verifies compliance with NQA-1-1994 specifications and RG 1.37.

04.05.02-5

Tools used in abrasive work on austenitic stainless steel surfaces are controlled per the requirements in RG 1.37 to prevent the introduction of contaminants that may promote stress corrosion cracking in accordance with GDC 14.

4.5.2.5 Other Materials

The hold-down spring is made from martensitic stainless steel, ASME SA-182 Grade F6NM. This martensitic stainless steel is delivered in the quenched and tempered condition. The material is tempered between 1040°F and 1120°F ~~(560°C and 604°C)~~ as required by the ASME material specifications.

04.05.02-1

The Stellite 6 or equivalent cobalt alloy is ~~only~~ used only in a ~~very small~~ portion of the reactor internals where an alternate material will not perform satisfactorily. It has a ~~very~~ low susceptibility to corrosion.

This material was selected for compatibility with reactor coolant, as described in ASME articles NB-2160 and NB-3120.

4.5.3 References

1. ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, "Class 1 Components," The American Society of Mechanical Engineers, 2004.

2. ASME Boiler and Pressure Vessel Code, Section II, Part C, "Specifications for Welding Rods, Electrodes and Filler Materials," The American Society of Mechanical Engineers, 2004.

3. NQA-1-1994, "Quality Assurance Requirements for Nuclear Facility Applications (QA)," ASME, The American Society of Mechanical Engineers, 1994.

4. ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, "Core Support Structures," The American Society of Mechanical Engineers, 2004.

Table 4.5-2—Reactor Vessel Internal Materials

Component	Material Specifications
Lower Internals Assembly	ASME SA-182 Grade F304LN ASME SA-336 Grade F304LN ASME SA-240 Type 304LN ASME SA-479 Type 304LN ASME SA-479 Type 316 Strain Hardened Level 1 (Code Case N-60-5) Carbon content shall be 0.03% or less ASME SB-168 UNS-N06690 ASME SB-637 UNS-N07750, Type 2 Stellite 6 or equivalent (hard facing)
Upper Internals Assembly	ASME SA-182 Grade F304LN ASME SA-376 Grade TP304LN ASME SA-240 Type 304LN ASME SA-479 Type 304LN ASME SA-479 Type 316 Strain Hardened Level 1 (Code Case N-60-5) Carbon content shall be 0.03% or less ~~Cobalt alloy~~ Stellite 6 or equivalent (hard facing)
Heavy Reflector	ASME SA-336 Grade F304N ASME SA-240 Type 304LN ASME SA-336 Grade F304LN ASME SA-479 Type 304LN ASME SA-479 Type 316 Strain Hardened Level 1 (Code Case N-60-5) Carbon content shall be 0.03% or less ~~Cobalt alloy~~ Stellite 6 or equivalent (hard facing)
Control Rod Guide Assembly	ASME SA-182 Grade F304LN ASME SA-240 Type 304LN ASME SA-479 Type 304LN ASME SA-376 Grade TP304LN
Hold Down Spring	ASME SA-182 Grade F6NM
Reactor Vessel Internals Welds	Type ~~304L~~/308L/309L/316L austenitic stainless steel per SFA 5.4, 5.9, or 5.22

04.05.02-3

04.05.02-1

04.05.02-3

04.05.02-1

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