RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**436-8538**
SRP Section:	**04.05.01 – Control Rod Drive Structural Materials**
Application Section:	**4.5.1**
Date of RAI Issue:	**03/08/2016**

Question No. 04.05.01-11

REGULATORY BASIS: GDC 14 and 26

ISSUE:

This RAI is a follow-up to RAI 303-8391, Question 04.05.01-02.

In the response to RAI 303-8391, Question 04.05.01-02, dated December 22, 2015 (ADAMS Accesion No. ML15356A554), the applicant proposed a revision to APR1400 FSAR Tier 2, Section 4.5.1.2 based on the following information:

> "...Meanwhile, there has been no SCC problem in the magnetic drive CEDMs of other CE plants with venting devices according to EPRI MRP-236[note 1] and MRP-352[note 2].
>
> It should be noted that the magnetic drive CEDM design of CE plants is almost the same as that of the OPR1000 and APR 1400, and therefore, venting is performed for the APR1400 CEDMs through the vent stem to eliminate the air trapped in the top of the CEDMs, compared with US and France plants which have adopted no venting practice in general and experienced SCC in CRD canopy seal welds. In addition, for the OPR1000 plants, the Versa VentTM and its operating tools have been used for venting the CEDMs, which are the CEDM servicing equipment to facilitate venting activities. This servicing equipment will be applied to APR1400 plants. [...]
>
> ...As shown in Figure 1, the Versa Vent^{TM} is substituted for the CEDM housing nut and installed into the top of the CEDM upper pressure housing assembly (UPHA) with its venting device.
>
> The CEDM housing nut is only installed into the top of the CEDM UPHA instead of the Versa Vent^{TM} and omega seal will be welded with CEDM housing nut when excessive

leakage occurs during normal operation and normal operation should be resumed immediately. The CEDM venting is impossible when the omega seal weld is applied. However, the omega seal weld is just made as a temporary repair to block the unacceptable leakage and it has never been made for the OPR1000 CEDMs so far.

Under normal operating condition, the pressure retaining boundary is composed of the CEDM UPHA and the vent stem (the ball seal is a sealing material.). Therefore, the Versa Vent^{TM} and its operating tools are not composed of the pressure retaining boundary. When the CEDM housing nut is installed and omega seal welded, the pressure retaining boundary is composed of the CEDM UPHA, vent stem, housing nut and an omega seal weld. The Versa Vent's housing nut is made of non-code and non-nuclear safety related material and no welding is allowed, while the CEDM's housing nut is made of code and safety class material."

The staff needs the following information to determine the pressure boundary components of the CEDM and the applicable operating experience:

a. Discuss the difference between the CE designed magnetic drive CEDM and the APR1400 magnetic drive CEDM, so that the staff can determine the applicability of the CE CEDM operating experience.
b. Explain when the Versa Vent^{TM} is installed, and how it is used during normal operation.
c. Since the Versa Vent^{TM} is substituted for the CEDM housing nut (which is pressure boundary), then the Versa Vent^{TM} should also be pressure boundary. Therefore, since the Versa Vent^{TM} is part of the pressure boundary, include the material specification and type in Section 4.5.1.1 of APR1400 FSAR.
d. Since the omega seal is not welded, and provides a vent between the housing nut and the upper pressure housing, discuss why the use of the Versa Vent^{TM} is necessary.

Include the appropriate DCD markups with the response.

Response

a. An APR1400 magnetic drive CEDM consists of upper pressure housing, motor housing, motor assembly, coil stack assembly, two reed switch position transmitter assemblies, and an extension shaft assembly. The APR1400 CEDM is essentially identical to the System 80 CEDM, which is presently operating at the Palo Verde Nuclear Generating Station. APR1400 CEDMs are driven by four coils and double-step mechanism, except for the material of the motor housing lower end fitting and thickness of the upper shroud tube. The material of the motor housing lower end fitting of APR1400 CEDM was changed to Alloy 690TT to improve structural integrity against PWSCC, and thickness of the upper shroud of APR1400 CEDM was increased to improve mechanical strength. The APR1400 CEDM is also same as the CEDMs presently in use on operating reactors such as Hanbit 3&4, Hanbit 5&6, Hanul 3&4, Hanul 5&6, Shin-kori 1&2 and Shin-wolsong 1&2 in Korea.

   Based on the above discussion, the experiences of CE designed magnetic drive CEDM can be applied to the APR1400 magnetic drive CEDM.

b. The Versa Vent^{TM} is installed at the initial installation phase of CEDM and venting is performed through the vent stem to eliminate the air trapped in the top of the CEDM. During normal operation the Versa Vent^{TM} is not used for venting. The Versa Vent^{TM} is used during the refueling period for venting.

c. The Versa Vent^{TM} is substituted for the CEDM housing nut and used for venting as long as the vent stem does not leak. In this case the pressure boundary consists of the upper pressure housing and vent stem, and the Versa Vent^{TM} is non pressure boundary. When the vent stem leaks excessively, the Versa Vent^{TM} is removed and CEDM housing nut is installed. In this leaking case the pressure boundary is changed to consist of the upper pressure housing and CEDM housing nut and omega seal weld. Venting is not possible when the CEDM housing nut and omega seal weld is applied. This is why the Versa Vent^{TM} is not pressure boundary.

d. Omega seal weld is applied between CEDM housing nut and upper pressure housing when leaks develop. When the Versa Vent^{TM} is installed and used for venting, the omega seal weld is not applied between the Versa Vent^{TM} housing nut and the upper pressure housing. The DCD markups of DCD Sec. 4.5.1.2 as per RAI 303-8391 Question 04.05.01-02 include this description.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**436-8538**
SRP Section:	**04.05.01 – Control Rod Drive Structural Materials**
Application Section:	**4.5.1**
Date of RAI Issue:	**03/08/2016**

Question No. 04.05.01-12

REGULATORY BASIS: GDC 14 and 26

ISSUE:

This RAI is a follow-up to RAI 303-8391, Question 04.05.01-05.

In the response to RAI 303-8391, Question 04.05.01-05, dated December 22, 2015 (ADAMS Accesion No. ML15356A554), the applicant proposed to revise Section 4.5.1.3 to include the material specifications AMS 5894 for Stellite 6B, and material specification AMS 5979 for Haynes alloy No. 25 and Haynes alloy No. 36. The staff requests the following information to ensure that the material properties of these components will be appropriate for these applications:

a. There is no material specification AMS 5979 for Haynes alloy Nos. 25 and 36. Provide the appropriate material specifications and include them in Section 4.5.1.3.

b. Include in APR1400 FSAR Tier 2, Section 4.5.1.3 the heat treatment (to include temperature, time and cooling, if applicable) to be applied to the Stellite No. 6B, Haynes alloy No. 25 and Haynes No. 36 materials, as previously requested.

Include the appropriate DCD markups with the response.

Response

a. The material specification for Haynes alloy Nos. 25 and 36 will be corrected from AMS 5979 to AMS 5759 and will be included in DCD Section 4.5.1.3 as attached mark-ups.

b. The Stellite No. 6B is supplied in the vacuum-annealed (solution annealed) condition by heating to 1232 ℃ (2250 °F) and air cool, and the Haynes 25 is in solution treatment condition at 1204 ℃ (2200 °F) and air cool. The Haynes 36 is supplied in aging condition at 732 ℃ (1350 °F) for 16 hours. The description on the heat treatment will be included in DCD Section 4.5.1.3 as attached mark-ups.

Impact on DCD

DCD 4.5.1.3 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Report.

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4.5.1.3 Other Materials

Springs are made of Alloy X-750. They conform with AMS 5698 or 5699 and are drawn from hot-finished wire or rod that has been previously ground or has had surface preparation to remove scale, seams, or other injurious surface imperfections. The wire is heat treated at about 1,149 °C (2,100 °F) before being reduced to size. The springs fabricated from these materials have no failure experience in Korea.

Revise
"Cobalt alloy of AMS 5894 for pins (i.e., Stellite No. 6B as bars), which is ordered in the vacuum-annealed condition, and AMS 5979 for latch and links (i.e., Haynes alloy No. 25 as bars or 36 as castings) are used."

Alloy 625 materials are us drawn and stress relieved hour.

Cobalt alloy (Stellite No. 6B), which is used for pins, is ordered in the vacuum-annealed condition. For the latch and link, the cast form of cobalt alloy (Haynes No. 36) is used.

Bearing inserts, alignment tab, and steel ball are made of martensitic stainless steel, which conforms with ASTM A279, Type 440C. The martensitic stainless steel that is supplied has been quenched and subzero-cooled after quenching.

The materials used in the CEDM that are not included in ASME Section III, Appendix I, Division 1 are identified in Subsections 4.5.1.1 b and c.

Thermally treated Alloy 690 (690TT), and Alloys 52/52M and 152 weld metals are used for the APR1400 DC design, and have shown excellent performance against PWSCC in field operations and laboratory experiments. Alloy 600 and Alloys 82/182 are not used. Resistance to PWSCC of Alloy 690, 52/52M, and 152 in pressurized water reactors is described in EPRI report MRP-111, "Resistance to Primary Water Stress Corrosion Cracking of Alloys 690, 52, and 152 in Pressurized Water Reactors." There are no reports of the cracking of Alloy 690, and the welds up-to-date (as of April 2012). Non-metallic materials are not used in the CEDMs.

Add "The Stellite No. 6B is supplied in the vacuum-annealed (solution annealed) condition by heating to 1232 ℃ (2250 ˚F) and air cool, and the Haynes 25 is in solution treatment condition at 1204 ℃ (2200 ˚F) and air cool. The Haynes 36 is supplied in aging condition at 732 ℃ (1350 ˚F) for 16 hours."

Revise "Cobalt alloy of AMS 5894 for pins (i.e., Stellite No. 6B as bars) and AMS 5759 for latch and links (i.e., Haynes alloy No. 25 as bars or 36 as castings) are used."

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

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Docket No. 52-046

RAI No.:	**436-8538**
SRP Section:	**04.05.01 – Control Rod Drive Structural Materials**
Application Section:	**4.5.1**
Date of RAI Issue:	**03/08/2016**

Question No. 04.05.01-13

REGULATORY BASIS: GDC 14 and 26

ISSUE:

This RAI is a follow-up to RAI 303-8391, Question 04.05.01-06.

In the response to RAI 303-8391, Question 04.05.01-06, dated December 22, 2015 (ADAMS Accesion No. ML15356A554), the applicant provided Table 4.5-1 which included the weld filler metal types used for the reactor coolant pressure boundary of the CEDMs. However, RAI 303-8391, Question 04.05.01-06 requested the filler metal specification as well as type. Therefore, include the applicable filler metal specification for each filler metal type in Table 4.5-1.

Include the appropriate DCD markups with the response.

Response

The Table 4.5-1 will be revised to include applicable filler metal specifications for each filler metal type for APR1400 CEDM.

Impact on DCD

DCD Table 4.5-1 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Report.

Add
"Table 4.5-1 Weld Filler Materials for Reactor Coolant Pressure Boundary of the CEDM .... 4.5-16"

ASTM A 276, Type 304 (austenitic stainless steel)

ASTM A 269, TP304 (austenitic stainless steel)

ASTM A 276, Type 410 Condition A (martensitic stainless steel)

2) Gripper

ASTM B 446, Alloy 625 (nickel-chromium-molybdenum-columbium alloy)

3) Spring

AMS 5699, Alloy X-750 (nickel-base alloy)

4) Pin

Revise
"The weld rod filler materials used with the reactor coolant pressure boundary components of CEDM are provided in Table 4.5-1."

Type 300 Series (austenitic stainless steel)

The functions of the extension shaft components are addressed in Subsection 3.9.4.

d. The weld rod filler materials used with the preceding components are Stainless Steel Type 308; Stainless Steel Type 316; and Alloy 52, 52M, and/or 152.

A CEDM using the materials listed above was tested to exceed the lifetime requirement, as described in Subsection 3.9.4. Operating experience that shows the successful performance of the materials is also applicable to the APR1400 CEDMs because they are essentially identical to the Palo Verde, Hanbit Units 3 through 6, Hanul Units 3 through 6, Shin-Kori 1&2, and Shin-Wolsong 1 CEDMs, which are all in operation. The experience has demonstrated that the CEDM operates without malfunction.

The CEDM structural material identified in Subsection 4.5.1.1 that has a yield strength greater than 620 MPa (90 ksi) is ASTM A 276, Type 440C, martensitic stainless steel. Its usage is limited to the steel ball in the vent valve on the top of the CEDMs, bearing inserts, and alignment tab in the motor assembly. The steel ball is used as a seal and is not a

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Table 4.5-1 Weld Filler Materials for Reactor Coolant Pressure Boundary of CEDM

Component	Base Material		Type of Weld	Filler Material
Upper pressure housing ass'y (Upper end fitting + Tube)	SA-479, Type 316	SA-213, Gr. TP316	Groove	ER316L, IN316L
Upper pressure housing ass'y (Tube + Lower end fitting)	SA-213, Gr. TP316	SA-479, Type 316	Groove	ER316L, IN316L
Motor housing ass'y (Upper end fitting + Motor housing tube)	SA-182, Gr. F347	Inconel buttered on Code case N-4-13	Groove	ERNiCrFe-7, ERNiCrFe-7A
Motor housing ass'y (Motor housing tube)	Code case N-4-13		Buttering	ERNiCrFe-7A
Motor housing ass'y (Motor housing tube + Lower end fitting)	Inconel buttered on Code case N-4-13	SB-166, N06690	Groove	ERNiCrFe-7, ERNiCrFe-7A

Replace:
Table 4.5-1 with the table on the following page (Attachment (4/4)).

Table 4.5-1 Weld Filler Materials for Reactor Coolant Pressure Boundary of the CEDM

Component	Base Material		Type of Weld	Filler Material	Material Specification
Upper pressure housing ass'y (Upper end fitting + Tube)	SA-479, Type 316	SA-213, Gr. TP316	Groove	ER316L	ASME Sec. II Part C SFA-5.9
Upper pressure housing ass'y (Tube + Lower end fitting)	SA-213, Gr. TP316	SA-479, Type 316	Groove	ER316L	ASME Sec. II Part C SFA-5.9
Motor housing ass'y (Upper end fitting + Motor housing tube)	SA-182, Gr. F347	Inconel buttered on Code case N-4-13	Groove	ERNiCrFe-7A	ASME Sec. II Part C SFA-5.14
Motor housing ass'y (Motor housing tube)	Code case N-4-13		Buttering	ERNiCrFe-7A	ASME Sec. II Part C SFA-5.14
Motor housing ass'y (Motor housing tube + Lower end fitting)	Inconel buttered on Code case N-4-13	SB-166, N06690	Groove	ERNiCrFe-7A	ASME Sec. II Part C SFA-5.14

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SRP Section:	**04.05.01 – Control Rod Drive Structural Materials**
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Question No. 04.05.01-14

REGULATORY BASIS: GDC 14 and 26

ISSUE:

This RAI is a follow-up to RAI 303-8391, Question 04.05.01-09.

In the response to RAI 303-8391, Question 04.05.01-09, dated December 22, 2015 (ADAMS Accesion No. ML15356A554), the applicant proposed to revise Section 4.5.1.1.b, to include the heat treatment condition of the ASTM A 276, Type 410 material. The response also specified that the tempering temperature will be higher than 565°C (1050°F), but did not include it in the proposed revision to Section 4.5.1.1.b.response also specified that the tempering temperature will be higher than 565°C (1050°F), but did not include it in the proposed revision to Section 4.5.1.1.b. Therefore, include in FSAR Section 4.5.1.1.b that the tempering temperature will be above 565°C (1050°F).

Include the appropriate DCD markups with the response.

Response

The DCD Section 4.5.1.1.b will be revised to include the sentence of tempering temperature that is higher than 565 ℃ (1050 ˚F) for the ASME A276 Type 410T materials as attached mark-ups.

Impact on DCD

DCD 4.5.1.1.b will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical or Environmental Report.

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endorsed in NRC RG 1.84 (Reference 6). The functions of the above-listed components are addressed in Subsection 3.9.4.

b. The parts and materials in contact with the reactor coolant used in the CEDM motor assembly components are as follows:

1) Latch guide tubes

ASTM A 269, Type 316 (austenitic stainless steel)

Chrome oxide (plasma spray treatment)

2) Latch magnet and center spacer

ASTM A 276, ~~Type 410~~ (martensitic stainless steel)

Revise "Type 410 Condition T"

Revise "Type 410 Condition T" (insert the following in next line) "The tempering temperature is higher than 565 °C (1050 °F)"

3) Lift magnet and latch spacer

ASTM A 276, ~~Type 410~~ (martensitic stainless steel)

Revise "Type 410 Condition A"

4) Latch housing and insert assembly

ASTM A 276, Type 316 (austenitic stainless steel)

SAE AMS 2460 (chrome plating)

ASTM A 276, Type 440C (martensitic stainless steel)

5) Spacer

ASTM A 240, Type 304 (austenitic stainless steel)

6) Alignment tab

ASTM A 276, Type 440C (martensitic stainless steel)

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7) Spring

AMS 5698, Alloy X-750 (nickel-base alloy)

8) Pin

Stellite No. 6B (cobalt-base alloy) or functionally equivalent material

9) Dowel pin

Type 300 Series (austenitic stainless steel)

Revise
"Type 410 Condition T"
(insert the following in next line)
"The tempering temperature is higher than 565 °C (1050 °F)"

10) Adjusting nut

ASTM A 276, Type 321 (austenitic stainless steel)

Revise
"Condition T"

11) Lower lift stop

ASTM A 276, ~~Type 410 condition T~~ (martensitic stainless steel)

12) Latch and link

Haynes No. 36 (cobalt-base alloy) or functionally equivalent material

13) Locking cup and screws

Type 300 Series (austenitic stainless steel)

The functions of the CEDM motor assembly components are addressed in Subsection 3.9.4.

c. The materials in contact with the reactor coolant used in the extension shafts are as follows:

1) Shafts, operating rod tube, and plunger