KHNPDCDRAIsPEm Resource

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Sent: Friday, December 18, 2015 4:30 PM
To: apr1400rai@khnp.co.kr; KHNPDCDRAIsPEm Resource; Harry (Hyun Seung) Chang; Andy Jiyong Oh; James(AECOM)
Cc: Lee, Samuel; Ciocco, Jeff; Honcharik, John; Mitchell, Matthew; Ward, William
Subject: APR1400 Design Certification Application RAI 341-8410 (5.4.1.1 - Pump Flywheel Integrity (PWR))
Attachments: APR1400 DC RAI 341 MCB 8410.pdf

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs. However, KHNP requests, and we grant, 60 days to respond to the RAI question. We may adjust the schedule accordingly.

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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REQUEST FOR ADDITIONAL INFORMATION 341-8410

Issue Date: 12/18/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 05.04.01.01 - Pump Flywheel Integrity (PWR)
Application Section: 5.4.1.1

QUESTIONS

05.04.01.01-1

Appendix A of 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," provides General Design Criteria (GDC) which establish minimum requirements for the principal design criteria for water-cooled nuclear power plants. Criterion 1, "Quality standards and records," and 10 CFR Part 50.55a(a)(1) require that SSCs important to safety shall be designed, fabricated, erected and tested to quality standards which shall be identified and evaluated to determine their applicability, adequacy, and sufficiency to assure a quality product in keeping with the required safety function. Because reactor coolant pump flywheels have large masses and rotate at speeds of 900 revolutions per minute (rpm) or 1200 rpm during normal reactor operation, a loss of flywheel integrity could result in high energy missiles and excessive vibration of the reactor coolant pump assembly. The safety consequences could be significant because of possible damage to the reactor coolant system, the containment, or the engineered safety features. Reactor coolant pump flywheel failure can result in reduction or loss of forced coolant flow. In following the standard review plan, NUREG-0800, section 5.4.1.1, "Pump Flywheel Integrity (PWR)," staff has determined that it must receive and review responses to the following requests for additional information before it can make its safety determination on the flywheel design.

APR1400 FSAR Section 5.4.1.1.2, "Fracture Toughness," states that:

> K_{IC} of the flywheel material at the normal operating temperature of the flywheel is greater than 165 MPa$\sqrt{m}$ (150 ksi$\sqrt{in}$). Conformance is demonstrated by an indirect test. Justification is provided to establish the equivalence of fracture toughness in the proposed flywheel material and certain steels (ASME SA-533-B Class 1, ASME SA-508 Class 2, ASME SA-508 Class 3, and ASME SA-516 Grade 65). The RT_{NDT} of the flywheel materials is determined in accordance with NB-2320 and NB-2330 of the ASME Section III.

The NRC requests the following:

a. Provide the method used to determine the fracture toughness.
b. Provide the justification that the flywheel material, 26NiCrMoV14-5, is equivalent to the steels specified above so that an indirect method of determining fracture toughness can be used. Otherwise, a direct method should be used, since this is the preferred method as stated in SRP 5.4.1.1, paragraph II.2, “SRP Acceptance Criteria.”
c. Provide the RT_{NDT} of the flywheel material.
d. Provide operating experience of the flywheel material, 26NiCrMoV14-5.

05.04.01.01-2

APR1400 Final Safety Analysis Report (FSAR) Section 5.4.1.1, "Pump Flywheel Integrity," states that the “flywheel uses a shrink fit design to couple it to a shaft.” APR1400 FSAR Section 5.4.1.1.3, "Design," references the supporting RCP flywheel analysis summarized in technical report APR1400-A-M-NR-14001-P, “KHNP APR1400 Flywheel Integrity Report,” Revision 0, dated November 2014, which details that the flywheel is shrink-fitted onto a hub, and this hub is shrink-fitted onto the shaft. Revise APR1400 FSAR Section 5.4.1.1 to be consistent with the flywheel design in the technical report.

05.04.01.01-3

APR1400 FSAR Section 5.4.1.1 references the supporting RCP flywheel analysis summarized in technical report APR1400-A-M-NR-14001-P, “KHNP APR1400 Flywheel Integrity Report,” Revision 0, dated November 2014. The NRC staff requests the following information concerning this technical report:

a. Paragraph 2.4, "Acceptance Criteria," of the technical report specifies that the total stress in the flywheel at standstill and normal operating speed does not exceed one-third of the ultimate tensile strength.” In addition, paragraph 5.11 specifies that “the total stresses in the flywheel at standstill and normal operating speed shall not exceed one-third of the minimum specified yield strength” and that the “total stresses is 38,674 psi.” Paragraphs 2.4 and 5.11 of the technical report are not consistent, and should state the total stresses should not exceed one-third of the minimum specified yield strength as stated in NRC Standard Review Plan (SRP) 5.4.1.1, paragraph II.4.a.

b. Section 5.11, "Evaluation of Stresses," of the technical report states that “one-third of the ultimate strength of 800/3 (N/mm^2) = 38,677 psi.” The NRC staff notes that one-third of the ultimate strength is actually 38,667 psi, and therefore, the calculated total stresses of the flywheel at normal operating speed of 38,674 psi exceeds 38,667 psi. Therefore, the calculated stresses do not meet the one-third of yield strength or one-third of ultimate tensile strength acceptance criteria. Therefore, the NRC staff requests that a flywheel design that meets the guidance and acceptance criteria of SRP 5.4.1.1 to be provided.

c. Paragraph 5.15, "Fatigue Crack Growth," of the technical report describes the fatigue crack growth rate for the flywheel, but not for the hub. In addition, paragraph 5.15 of the technical report specifies that “the fatigue crack growth due to 6,000 cycles from standstill to normal operation can be predicted by the fatigue crack growth rates available in reference 5 [ASME Code, Section III, Division 1, Appendix A].” Revise the technical report to provide justification that the fatigue crack growth rates used apply to the flywheel material. In addition, this analysis should also be done on the hub since it is a critical part that attaches the flywheel to the shaft, and a potential hub failure could release the flywheel as a missile.

d. Submit reference 6 (Siemens Document, 4D5.0170.83-575711F, Revision F, “Flywheel Calculation,” May 30, 2011) from the technical report to support the staff’s review of the APR1400 design.

05.04.01.01-4

APR1400 FSAR Section 5.4.1.1.4.f, "Test and Inspection," states that, “Each flywheel receives a preservice baseline inspection that incorporates the methods defined above for an inservice inspection. Examination procedures and acceptance criteria are determined in accordance with ASME Section III.”

Revise APR1400 FSAR Section 5.4.1.1.4.f to state the acceptance criteria that will be used for the inspection. In addition, specify in the FSAR whether the maximum flaw size used as the acceptance criteria for this inspection is bounded by the flaw size used in determining the critical flaw size in Technical Report APR14001-A-M-NR-14001-P, Rev. 0.

05.04.01.01-5

Technical Report APR14001-A-M-NR-14001-P, “KHNP APR1400 Flywheel Integrity Report,” Revision 0, dated November 2014, Section 3.1, "Stresses and Radial Displacement Due to Shrink Fit of Sections of Flywheel," details that the flywheel is shrink-fitted onto a hub, and this hub is shrink-fitted onto the shaft. Therefore, since the hub can affect the integrity of the flywheel if it fails and releases the flywheel as a potential missile, the test and inspections proposed in APR1400 FSAR Section 5.4.1.1.4 for the flywheel should also apply to the hub.

Revise APR1400 FSAR Section 5.4.1.1.4 to specify that the tests and inspections proposed for the flywheel will also apply to the hub. Also, include whether the hub can be inspected without the removal of the flywheel from the pump.

05.04.01.01-6

APR1400 FSAR Section 5.4.1.1.4 specifies an inservice inspection program that includes ultrasonic examinations of the keyway in the flywheel. However, Technical report APR1400-A-M-NR-14001-P, “KHNP APR1400 Flywheel Integrity Report,” Revision 0, dated November 2014, does not show that the flywheel has a keyway, nor is one described. Therefore, provide a drawing of the flywheel design, so that NRC staff can confirm whether the flywheel has a keyway. Also, revise the Technical report APR1400-A-M-NR-14001-P, “KHNP APR1400 Flywheel Integrity Report,” Revision 0, dated November 2014, and APR1400 FSAR Section 5.4.1.1.4, as necessary, to be consistent with the actual flywheel design.