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.:	**541-8724**
SRP Section:	**06.02.05 – Combustible Gas Control in Containment**
Application Section:	**6.2.5**
Date of RAI Issue:	**02/21/2017**

Question No. 06.02.05-12

This is a follow up question to KHNP's response to RAI 155-8167, Question 6.2.5-4, regarding passive autocatalytic recombiner (PAR) recombination rates.

10 CFR 52.44(c)(1) requires that a standard design certification applicant must ensure a mixed atmosphere in containment during design-basis and significant beyond design basis accidents. A mixed atmosphere means that the concentration of combustible gases in any part of the containment is below a level that supports combustion or detonation that could cause loss of containment integrity.

APR1400 Design Control Document (DCD) Tier 2, Section 6.2.5 credits the passive autocatalytic recombiners (PAR) with meeting the above criteria.

However, in DCD Tier 1, Table 2.11.4-1, "Containment Hydrogen Control System ITAAC," there is insufficient information to determine that the containment hydrogen control system design meets the above criteria. In DCD Tier 2, Table 6.2.5-1, "Location of PARs and His," PAR and hydrogen igniters (HI) locations in containment are provided. This information should either be included in Tier 1, Table 2.11.4-1, or a link to Tier 2, Table 6.2.5-1 should be provided in Tier 1, Table 2.11.4-1.

Also, DCD Tier 2, Table 6.2.5-1 describes the PARs as "small, middle, large." The actual PAR recombination rates which form the basis of the hydrogen containment analysis should be provided in the DCD.

The response stated that the equation for the recombination rate for the large (FR1-1500) PARs has the two coefficients, A and B. The staff's review indicates that these coefficients, A and B, should be larger. These coefficients were deduced by comparing the recombination rate that is predicted by the formula to the performance specifications published for an AREVA PAR.

KHNP's response to RAI 472-8564, Question 6.2.5-11, confirmed the larger coefficients above were used by KHNP in their analyses. This is in agreement with the coefficients used in staff's MELCOR confirmatory calculation.

In the original RAI 155-8167, question 6.2.5-4, staff also requested the following:

DCD Tier 2, Table 6.2.5-1 describes the PARs as "small, middle, large." The actual PAR recombination rates which form the basis of the hydrogen containment analysis should be provided in the DCD, either:

- Into both Tier 2, Table 6.2.5-1 and Tier 1, Table 2.11.4-1, or
- Into just Tier 2, Table 6.2.5-1, with a link to Tier 2, Table 6.2.5-1 being provided in Tier 1, Table 2.11.4-1.

Please provide the recombination rates of the three sizes of PARs which establish the capacity of the containment hydrogen control system.

Response

The performance criteria for depletion rates of PARs are provided in the following table. This information will be added to DCD Tier 2 Table 6.2.5-3 as shown in Attachment 1

Performance criteria for depletion rates of PARs

Condition / Size	Hydrogen 4%	Hydrogen 8%
Small	0.9 kg/hr	1.8 kg/hr
Medium	1.8 kg/hr	3.6 kg/hr
Large	4.0 kg/hr	8.0 kg/hr

Tier 1 is a standalone document that should both minimize the amount of design-level data subject to revision and not contain links to DCD Tier 2. Attachment 2 reflects these revisions.

Impact on DCD

DCD Tier 2, Subsection 6.2.5.2.1 and 6.2.9 will be revised and Tier 2, Table 6.2.5-3 will be added as indicated in Attachment 1 associated with this response.

DCD Tier 1, Tables 2.11.4-1 will be revised as indicated in the Attachment 2 associated with this response.

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.

The PARs in the containment and inside the IRWST vent stack, and the HIs in the containment are designed to withstand severe accident conditions. The PARs and HIs provide reasonable assurance that the equipment can perform its identified function during severe accident conditions as described in Section 19.2.

PARs are considered a 15 percent efficiency reduction for iodine vapor and 10 percent efficiency reduction for cable fire. Thus, a total 25 percent efficiency reduction for the PAR was considered for capacity reduction. The HIs include a consideration of the combustion model of the MAAP computer code.

The PARs and HIs are designed to prevent any significant pocketing of hydrogen in order to minimize the potential for localized hydrogen detonation.

The PARs and HIs are able to withstand the effects of their own operations and are designed to provide reasonable assurance that equipment necessary for achieving and maintaining a safe shutdown of the plant and containment integrity are capable of performing their functions during and after their exposure to hydrogen burning.

The PARs and HIs are located throughout the containment open volumes and compartments. The following location criteria are used:

a. Flow path requirements

b. Consideration of enclosed spaces

c. Equipment performance efficiency

d. Installation and maintenance

e. Consideration of dynamic effect

For the surveillance test of PARs, a sample of the PAR cartridges or plates is selected and removed from each PAR. Surveillance bench tests are performed on the removed specimens to confirm continued satisfactory performance. The HIs are capable of attaining the surface temperature that is sufficient for igniting hydrogen gases under any environmental conditions including CS actuation. The HI configuration, including possible spray shields, is supported by combustion test data.

The performance criteria for depletion rates of PARs is provided in Table 6.2.5-3.

Table 6.2.5-2 (6 of 6)

Name/Valve No.	Potential Failure Mode	Plant Condition	Symptoms and Local Effect Including Dependent Failure	Method of Detection	Inherent Compensating Provision	Remarks and Other Effects
6. Channel B containment monitor discharge to containment CM-010	a) Fails to open on demand	Detection of hydrogen in containment building	• No safety-related impact on plant • Isolation is achieved by redundant valve	Valve information: • Valve position indication in MCR	Isolation is achieved by redundant containment isolation valve (CM-009)	• Normally closed • Fail closed
	b) Fails to close on demand	• Loss of electrical power • Receipt of high containment pressure signal • Receipt of low pressurizer pressure signal	• No safety-related impact on plant • H_2 monitoring line is formed in the closed loop		H_2 monitoring line is formed in the closed loop	

← add Table 6.2.5-3 in next page

Table 6.2.5-3

Performance criteria for depletion rate of PARs

Condition / Size	Hydrogen concentration 4 v/o (percent by volume)	Hydrogen concentration 8% (percent by volume)
Small	0.9 kg/hr	1.8 kg/hr
Medium	1.8 kg/hr	3.57 kg/hr
Large	4.01 kg/hr	8.04 kg/hr

1) This PAR performance criteria uses PAR depletion rate equation from MAAP manual (Reference 43)

2) Performance criteria is hydrogen depletion rate at 1.5 bar, 60oC condition, and it also considers the 25%degradation in PAR performance.

39. ASME Section III, Division 1, Article NE 2300, “Fracture Toughness Requirements for Material,” The American Society of Mechanical Engineers.

40. NUREG-0800, Section 6.2.1.2, “Subcompartment Analysis,” Rev. 3, U.S. Nuclear Regulatory Commission, March 2007.

41. NRC RG 1.141, “Containment Isolation Provisions for Fluid Systems.”

42. APR1400-E-P-NR-14003-P(Proprietary)&NP(Non-Proprietary) “Severe Accident Analysis Report,” Rev. 1 KHNP, February 2017.

43. FAI/12-0005, "MAAP 4.0.8 Transmittal Document," Electric Power Research Institute, February 2012.

Table 2.11.4-1

Containment Hydrogen Control System Components List

Component Name	Item No.	Location[(1)]	ASME Section III Class	Seismic Category	Class 1E/Harsh Envir. Qual.	Display/ Control at MCR	Display/ Control at RSR	Control Signal	Active Safety Function	Loss of Motive Power Position
Passive Autocatalytic Recombiner	HR01A/01B ~ HR15A/15B	Containment	-	I	-/-	-/-	-/-	-	No	-
Hydrogen Igniter	HI01 ~ HI08	Containment	-	I	No/-	Yes/Yes	Yes/Yes	-	No	-
Containment Temperature Element	CM-TE-031A	Containment	-	I	Yes/Yes	Yes/No	Yes/No	-	No	-

(1) ~~Location of PARs and His are provided in DCD Tier 2, Table 6.2.5-1~~

(2) Dash (-) indicates not applicable.

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