

Technical Consultation on Evaluation of In-Vessel Retention Performance for APR1400 Using In-Vessel Injection

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KEPCO ENGINEERING & CONSTRUCTION COMPANY, INC.

1. Name of Service

Technical Consultation on Evaluation of In-Vessel Retention Performance for APR1400 Using In-Vessel Injection

2. Objectives of Service

The reactor core continues to generate decay heat even after core is damaged, and this may cause the Reactor Pressure Vessel (RPV) failure unless there is any mitigation system. External Reactor Vessel Cooling (ERVC) feature is applied in APR1400 for In-Vessel Retention (IVR) Strategy. However, it is not enough to assure that Reactor Pressure Vessel (RPV) retain molten core at all cases using the feature whereas In-Vessel Injection System (IVIS) can remove a large amount of heat from the core so that the integrity of the Reactor Pressure Vessel (RPV) could be ensured as long as it is taken at the right time with sufficient injection flow.

The objective of this service is to provide KEPCO E&C with a certain engineering consulting service for the evaluation of In-Vessel Retention Performance for APR1400 Using In-Vessel Injection.

This service is a part of the project which is “ARR1400 Design optimization service for export to Europe/Middle East applying the latest European requirements” ordered by KHNP.

3. Project Description

KEPCO-E&C is evaluating a strategy to provide an in-vessel injection to prevent a vessel failure during a severe accident for APR1400. If a severe accident were to occur in a nuclear reactor, it would be due to inadequate heat removal brought about by either a loss of coolant or a loss of sufficient heat removal capacity as might be the case in a station blackout scenario. Given such a state, the most important objective of accident management actions is to establish cooling of the nuclear fuel. A favorable severe accident management strategy is to retain the molten corium within the reactor vessel by depressurizing the RCS and providing in-vessel coolant to the RPV.

KEPCO E&C therefore aims to get a technical support with respect to evaluation of in-vessel retention performance from the Contractor.

4. Scope of Work

MAAP5.06 uncertainty runs for selected representative sequences to evaluate the in-vessel retention of core materials shall be performed. The performance for recovery from a damaged core and address its uncertainty should be provided.

Task 1 Uncertainty Analysis for IVR performance

Typical sequences could be SBO, loss of feedwater, small LOCA, and medium LOCA. KEPCO-E&C and the Contractor will discuss and finalize the sequences. Uncertainty analysis for estimating performance of the core melt arrest in vessel shall be as below.

- Select important MAAP parameters affecting the core melt progression and in-vessel retention.
- For each parameter, define probability distribution between the minimum and the maximum values.
- Uncertainty analysis for given MAAP parameters and probability distribution using Latin Hypercube Sampling (LHS)
- Create MAAP input decks for uncertainty analysis
 - up to 5 base cases with up to 5 recovery times per base case
 - up to 100 uncertainty cases for each recovery time and base case combination
- Determine the occurrence probability of core melt arrest in vessel (or recovery from a damaged core) from the results of uncertainty study
 - Evaluate ERDS opening time
 - Evaluate in-vessel injection time
 - The SKN5&6 parameter file and include files from KEPCO-E&C shall be used for this project.

Task 2 Meetings

- Kick-off meeting: Within approximately one month after the project has commenced, KEPCO E&C and the Contractor shall have a kick-off meeting. The topics to be discussed during the meeting include:
 - The background of core and reactor coolant system (RCS) model related to the IVR performance in MAAP code
 - A discussion for specific goals, scope, tasks, methodologies and conditions.
- Final meeting: Approximately two weeks prior to the end date of the project, KEPCO E&C and the Contractor shall have a technical meeting. During this meeting, the Contractor shall prepare:
 - The review of the results and conclusions
 - A discussion for future work, if necessary
- The two meetings shall be organized at the office in Korea once and via video conference once. Details of the venue and manner of the meetings will be discussed.

Task 3 Documentation and QA

As results of Task 1, a draft and final report describing the inputs and the results are provided as below. The inputs and report shall be QA reviewed.

- Run all the MAAP cases, check results, and debugging.
- Draft and final report summarizing inputs and results.
- Perform QA review of results.

5 Documentation of Consulting Results

All products for this consulting service shall be submitted in the form of electronic files. Electronic files of review results shall be submitted by the scheduled date. The consultation documentation will include all information for KEPCO E&C's questions made within the individual consulting period. In addition, reference materials when used in doing consulting work shall be identified in each consulting products, and a relevant electronic file may be provided (excluding legally restricted material) as requested by KEPCO E&C.

The Contractor shall not use nor disclose, to any third party, all and any information provided by KEPCO E&C in connection with this Contract. The Contractor shall promptly destroy, upon completion or termination of the Contract, whichever is earlier, all such information including but not limited to prepared, developed or generated information, document, material or any tangible information by the Contractor without retaining a copy of any such information. The Contractor shall upon request, certify in writing such destruction within reasonable period.

6. Methods of Performance

The Contractor shall keep confidential all the data and information from this Contract, and shall not divulge them to any third parties. The Contractor shall start the service according to the 8. Work Schedules, and issues arising during the consulting shall be resolved through Technical review meetings or in writing (document, e-mail).

7. Deliverables

All deliverables shall be submitted within period specified below.

- 1) Draft report : Within 4.5months from Execution Date
- 2) Final report including all inputs used : Within 6 months from Execution Date

8. Work Schedules

The period of performance will commence on the Execution Date of the Contract. The project schedule duration is estimated to be 6 months and the following is the schedule.

■ Schedule of Task Performance

Task	Schedule (Month)					
	1	2	3	4	5	6

1. Uncertainty Analysis						
2. Meetings						
3. Documentation and QA*				**		***

*** Draft Report and Final Report shall be submitted within 4.5 months and 6 months, respectively, from Execution Date.**

**** Review and clarifications from KEPCO E&C**

***** Final version which reflects all previous comments and clarifications**