

Technical Information

**Technical Consulting Services on Human Reliability
Analysis for SKN 5&6**

Nov., 2021



한국전력기술주식회사
KEPCO ENGINEERING & CONSTRUCTION COMPANY, INC

[SCOPE OF SERVICES AND METHOD OF PERFORMANCE]

1.0 PURPOSE

Korea Hydro and Nuclear Power Co., Ltd. (hereinafter called “KHNP”) has designated KEPCO E&C as a prime contractor for architect engineering services and related services for Shin-Kori Nuclear Power Plant Units 5 & 6 and has entered into a contract for such services to construct nuclear power plants of total nominal capacity of 2,800 MWe consisting of two identical units, which will be located in Haemaji-ro, Seosaeng-myeon, Ulju-gun, Ulsan Metropolitan City, Korea (SKN 5&6).

The purpose of this work scope is the evaluation of human error probabilities (HEPs) and review of consistency and uncertainty for SKN 5&6 probabilistic safety assessment (PSA)/human reliability analysis (HRA). This work will be performed to meet the Korea Regulation Guide that requires the accordance with the ASME Standard Capability Category II requirements, which should include the plant specific analysis, for the articles presented in “ASME/ANS RA-Sa 2009, Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, February 2009”.

Therefore, in order to incorporate the up-to-date HRA methodology for the analysis of human failure events (HFEs) and review of their consistency and uncertainty for internal and external PSA/HRA, KEPCO E&C aims to get technical support from the Contractor to accomplish the following goals:

- Analyses of HFEs and evaluate their HEPs for Level 1 and Level 2 PSA/HRA including internal and external (internal flood, internal fire, seismic) events.
- Analyses of HFEs related system or equipment for MACST (Multi-barrier Accident Coping Strategy) and evaluate their HEPs for Level 1 and Level 2 PSA/HRA including internal and external (internal flood, internal fire, seismic) events.
- Dependency analysis between HFEs for Level 1 and Level 2 PSA/HRA including internal and external (internal flood, internal fire, seismic) events.
- Review of consistency and uncertainty for HFEs on PSA/HRA

2.0 TECHNICAL SCOPE OF WORK

Contractor shall provide technical consulting services to KEPCO E&C for supporting SKN 5&6 PSA/HRA as described in the following tasks:

Task 1. Support for MACST HRA

- Task 1-1. Training of MACST HRA Methodology
 - (1) HRA methodology for the analysis of HFEs related to MACST
 - A 3 day MACST HRA training course.
 - Analysis methodology of human actions for MACST including identification, definition, qualitative analysis and quantitative analysis on internal and external event PSA/HRA.

- Examples of actual analyses for MACST HRA on U.S plants.
- Application of EPRI HRA Calculator for MACST HRA.
- (2) Results
 - Training materials for MACST HRA
- Task 1-2. Support and results review for MACST HRA on internal event
 - (1) Support for MACST HRA on internal events
 - Analysis support for human actions of MACST HRA on internal event.
 - Review of analysis examples for MACST HRA on internal event performed by KEPCO E&C.
 - (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of MACST HRA on internal event.
- Task 1-3. Support and results review for MACST HRA on external events
 - (1) Support for MACST HRA on external (internal flood, internal fire, seismic) events
 - Analysis support for human actions of MACST HRA on external events.
 - Review of analysis examples for MACST HRA on external events performed by KEPCO E&C.
 - (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of MACST HRA on external events.

Task 2. Support for HRA Dependency Analysis

- (1) Support Dependency Analysis between HFEs
 - Identification method for HFE combinations.
 - Dependency analysis method for portable equipment actions
 - Dependency analysis method between HFEs for Level 1 and Level 2 PSA.
 - Application of minimum joint HEP.
- (2) Results
 - Response to KEPCO E&C's questions or requests.

Task 3. Review of Consistency and Uncertainty

- Task 3-1. Consistency Review for Analysis of HFEs
 - (1) Consistency review for analyses and results
 - Consistency review for internal event HRA.
 - Consistency review for external events HRA.
 - (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Consistency review comments report and HRA calculator file for internal and external events HRA.
- Task 3-2. Uncertainty Review for Analysis of HFEs
 - (1) Support for uncertainty review of HFEs analyses
 - Uncertainty review for analysis examples of HFEs on internal event performed by KEPCO E&C
 - Uncertainty review for analysis examples of HFEs on external event performed by KEPCO E&C
 - (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Uncertainty review comments report and HRA calculator file for analysis examples of HFEs on internal and external events.

Task 4. Support for Level 1 and Level 2 Internal Event HRA

- (1) Support for analysis of HFEs on Level 1 and Level 2 internal event
 - Feasibility.
 - Screening value.
 - Cognitive modeling.
 - Execution modeling.
 - Application of recovery factors and assessment of dependencies for cognition and execution in single HFE.
 - Review of analysis examples for Level 1 and Level 2 internal event HRA performed by KEPCO E&C.
- (2) Results

- Response to KEPCO E&C's questions or requests.
- Review comments report and HRA calculator file for analysis examples of Level 1 and Level 2 internal event HRA.

Task 5. Support for Internal Flooding HRA

- (1) Support for analysis of HFEs on internal flooding event
 - Identification of additional PSFs or considerations for HFEs of internal flooding and detailed analysis methodology.
 - Identification and analysis of additional HFEs for internal flooding (e.g., flood mitigation actions).
 - Analysis support of existed internal event HFEs for internal flooding including feasibility, screening and detailed analysis.
 - Review of analysis examples for internal flooding HRA performed by KEPCO E&C.
- (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of internal flooding HRA.

Task 6. Support for Seismic HRA

- (1) Support for analysis of HFEs on seismic event
 - Identification of additional PSFs or considerations for HFEs of seismic and detailed analysis methodology
 - Identification and analysis of additional HFEs for seismic (e.g., chattering relay reset and its effect to operator response)
 - Analysis support of existed internal event HFEs for seismic including feasibility, screening and detailed analysis.
 - Review of analysis examples for seismic HRA performed by KEPCO E&C.
- (2) Results
 - Response to KEPCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of seismic HRA.

Task 7. Support for Fire HRA and Fire PSA Modeling

- Task 7-1. Review of Fire HRA based on NUREG-1921
 - (1) Support for analysis of HFEs on fire
 - Support for fire HRA and analysis of related HFEs according to NUREG-1921.
 - Review of analysis examples for fire HRA performed by KEPSCO E&C (except for MCR abandonment).
 - (2) Results
 - Response to KEPSCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of fire HRA.
- Task 7-2. Support of Fire Modeling for MCR and HRA Modeling for Main Control Room Abandonment (MCRA)
 - (1) Fire modeling for MCR and MCRA
 - Identification and characterization for two sample APR1400 control room.
 - Calculation of the MCR abandonment times.
 - Assessment for the effects of ventilation on the bounding baseline fire model calculation.
 - Evaluation of the NUREG-2178 Volume 2 MCB event tree for the analog Safety Console.
 - Overall process for calculating the Non-Suppression Probability (NSP) for non-MCB abandonment.
 - Considerations for additional MCR fire scenarios.
 - Approaches for determining model V&V basis and calculating and integrating model and parameter uncertainty.
 - (2) Support of HRA for MCRA
 - Support for analysis of HFEs for MCRA.
 - Review of analysis examples for HFEs on MCRA performed by KEPSCO E&C.
 - (3) Results
 - Response to KEPSCO E&C's questions or requests.
 - Review comments report and HRA calculator file for analysis examples of HFEs on MCRA.
 - Results of fire modeling for MCRA
- Task 7-3. Q&A for Fire HRA and Fire Modeling
 - (1) Meeting for Q&A with Contractor
 - A 4 day Meeting about Q&A for Task 7-1 and 7-2

(2) Results

- Response to KEPCO E&C's questions or requests.

Task 8. Progress / Wrap up Meeting

- One time meeting for PRM or Wrap up.
- Face to face meeting for 2.5 days

3.0 METHOD OF PERFORMANCE

Consulting Schedule

The contract period shall be 10 months from the Execution Date.

Action Items	1	2	3	4	5	6	7	8	9	10
Task 1 ¹⁾										
Task 2 ¹⁾										
Task 3 ¹⁾										
Task 4 ¹⁾										
Task 5 ¹⁾										
Task 6 ¹⁾										
Task 7 ¹⁾										
Task 8 ^{1),2)}	TBD									

1) The schedule can be adjusted by agreement between KEPCO E&C and Contractor.

2) Detailed schedule of Task 8 can be adjusted according to progress regarding each Task.

Method of Performance

- KEPCO E&C will provide related information and documents after signing of the contract, and will communicate and have discussions to expedite the progress of each task.
- The Contractor shall submit each deliverable of each Task within each Date of Submittal. The Contractor shall submit each draft report and HRA calculator file of each Task one month prior to each Date of Submittal. The Contractor shall finalize and submit each report to incorporate KEPCO E&C's review comments and their resolutions within Date of Submittal.
- For the Task 1-1, 7-3, and 8, KEPCO E&C will visit Contractor's office and the Contractor shall conduct the face-to-face training or meeting with related experts.
 - If KEPCO E&C cannot visit Contractor's office and the training or meeting cannot be conducted face-to-face due to any reason (for example, COVID-19) then a virtual training or meeting is possible.

- For the Task 7-3, KEPCO E&C will provide agenda prior to the meeting

- The Contractor shall provide each response to the question or request of KEPCO E&C within 5 working days. The response schedule can be adjusted by agreement between KEPCO E&C and the Contractor.

Deliverables

Tasks	Activities/Deliverables	Date of Submittal
1	(1) Training materials for MACST HRA (2) Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C	(1) By 5 days before training start ¹⁾ (2) Within 7 months after Execution Date
3	Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C	Within 7 months after Execution Date
4	Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C	Within 7 months after Execution Date
5	Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C	Within 7 months after Execution Date
6	Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C	Within 7 months after Execution Date
7	(1) Review comments report and HRA calculator file for analysis examples performed by KEPCO E&C (2) Results of fire modeling for MCRA	(1) Within 7 months after Execution Date (2) Within 10 months after Execution Date
1~7	Response to KEPCO E&C's questions or requests	Within 5 days after KEPCO E&C's request ²⁾
8	Meeting minutes	Within 5 days after meeting

- 1) If the training material is changed during the training, revised training material shall be provided within 10 working days after completion of training.
- 2) The response schedule can be adjusted by agreement between KEPCO E&C and the Contractor.