

[Technical Information]

**Technical Service for the Seismic Probabilistic Safety
Assessment and Probabilistic Ultimate Pressure
Capacity Evaluation on Shin-Kori NPP Unit 5&6**

2021. 7



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1. GENERAL INFORMATION OF THE SERVICE

Contractor shall perform tasks for Shin Kori 5&6 Nuclear Power Plants (hereafter, SKN 5&6) as below.

- Task 1. Equipment Seismic Fragilities Evaluation
- Task 2. Review of Plant Response Analysis performed by KEPCO E&C
- Task 3. Probabilistic Ultimate Pressure Capacity Evaluation
- Task 4. Seismic Walkdown Support
- Task 5. Licensing support
- Task 6. EPRI SQUG (Seismic Qualification Utility Group) training program support

Seismic fragility calculations for the SSCs shall be performed using the Separation-of-Variables approach (SOV) , Hybrid method using Conservative Deterministic Failure Margin method (CDFM) based on ASME/ANS PRA Standard (RA-Sb-2009, Part 5-SFR), based on the SSE response provided by KEPCO E&C. The review on plant response analysis results developed by KEPCO-E&C shall be performed by following ASME/ANS RA-Sb-2009, Part 5-SPR.

Probabilistic Ultimate Pressure Capacity Analysis shall be performed by recent methodology (i.e., 3D finite elements method, 3D FEM) by which the Contractor has an experience to adapt to existing nuclear power plants.

The technical services under the Contract is dominated to the prime contract summarized as below.

- A. Title : SHIN-KORI NUCLEAR UNITS 5&6 FOR ARCHITECT ENGINEERING
- B. Owner : KHNP
- C. Prime contract No. : NSKC-14P0001
- D. Period : 2014/04/11 ~ 2023/03/31

This technical service is for being supported to obtain operating license of SKN 5&6 to meet the prime contract requirement, ASME/ANS PRA Standard 2009.

2. SCOPE OF THE SERVICE

Detailed contents of tasks are as following;

- Task 1 – Equipment Seismic Fragilities Evaluation

- **Seismic fragility analysis on 50EA BOP and Distribution system equipment**
 - Usage of SOV or Hybrid method using CDFM, but risk dominant equipment shall be analyzed by SOV.
 - Electrical, mechanical equipment and distribution system and small instrument (Cabinets, Panels, Tanks, Pumps, Coolers, Heat Exchangers, Piping and its support, HVAC and its support, Cable tray and its support, and small instrument including transmitters, indicators, thermometer, etc.)
 - Items above are to be determined by KEPCO-E&C.
- **Review of 5EA Reactor Coolant System equipment (RCS) fragility analysis results done by KEPCO E&C**
 - Reactor Vessel
 - Reactor Vessel Internal
 - Steam Generators
 - Pressurizers
 - Reactor Coolant Pumps
- **Representative Calculations submittal to provide for KHNP**
 - Total two (2) representative calculations submittals; 1 EA fragility calculation of seismic qualified by analysis, and 1 EA fragility calculation of seismic qualified by testing
 - These two (2) calculations shall be selected among 50EA equipment above by KEPCO E&C.
 - “Representative Calculation” means “the calculation which do not have the inputs of SKN 5&6 plant-specific information”. Generic information will be provided by KEPCO E&C.
- **Submittal of equipment fragility calculations, review results and reports**
 - 50EA equipment calculations
 - 5EA review results of RCS fragility analysis results done by KEPCO E&C
 - 2EA representative calculations
 - 1EA final equipment fragility report

Task 2 – Review on Plant Response Analysis Results developed by KEPCO-E&C

- Review the screening level
- Review the initiating events
- Review the method of calculating seismic initiating event frequency
- Review the ET/FT including the seismic failure event of SSCs (Level 1&2)
- Review the Uncertainties/Sensitivities
- Review the result of seismic CDF (Core damage Frequency) / LERF (Large Early Release Frequency)
- Submittal of 1 (one) SPRA Review Report

Task 3 – Probabilistic Ultimate Pressure Capacity Evaluation (PUPCE)

- General Failure mode PUPCE including Shell&dome and foundation
- Local Failure mode PUPCE including Shell&dome and foundation
- Crack PUPCE of Liner plate or Shell&dome about Equipment Hatch and Personal Airlock
- Buckling PUPCE of Equipment Hatch and Personal Airlock
- Critical opening fracture failure PUPCE
- Opening sealing failure PUPCE
- Buckling PUPCE of Liner plate
- Low Power Shutdown state (LPSD) PUPCE of Equipment Hatch
 - * LPSD information will be provided by KEPCO E&C
- All PUPCE Calculations (including analysis model, input & output electronic files, other all auxiliary electronic files needed for PUPCE)
- Shall meet RAI (Request Additional Information) requirement by Korea Institute of Nuclear Safety (KINS) as following;
 - **Adequacy of Material model and uncertainty**
 - **Adequacy of Failure mode**
 - **Adequacy of Fragility analysis methodology (PUPCE)**
 - **Adequacy of Analysis (3D FEM)**
 - **Adequacy of Analysis modeling and its uncertainty**
 - **Adequacy of Failure Criteria**
 - **Adequacy of Fragility curve convolution by failure mode**

- Adequacy of LPSD PUPCE
- Review of Licensing requirement and PUPCE technical criteria abroad

Task 4 – Seismic Walkdown Support

- One (1) person, 2 weeks SKN 5&6 seismic walkdown support in Korea
- Critical risk dominant equipment (including distribution system) seismic walkdown
- Submittal of seismic walkdown report
 - * Detailed walkdown schedule will be addressed by KEPCO E&C.
- Performance of task 4 is to be specified and determined by an additional separate work order by KEPCO E&C at the beginning of task 4.
- The work order specifies the time, duration and methodologies for task 4 with mutual agreement between Contractor and KEPCO E&C.

Task 5 – RAI (Request for Additional Information) Support for licensing

- RAI support for Equipment seismic fragilities results
- RAI support for UPCE results
- Performance of RAI supports above is to be specified and determined by an additional individual work order by KEPCO E&C at the beginning of each RAI.
- The work order specifies the time, duration and methodologies for each RAI with mutual agreement between Contractor and KEPCO E&C.

Task 6 - EPRI SQUG (Seismic Qualification Utility Group) training program support

- KEPCO E&C two (2) Engineers to participate in SQUG training program support
- This program is needed for qualifying SCE (Seismic Capability Engineer) requirement for SKN 5&6 Seismic Walkdown.
- The Contractor shall enroll KEPCO E&C people (2 person) in EPRI SQUG training program in agreement regarding the time and expense with KEPCO E&C.
- Performance of task 6 is to be specified and determined by an additional separate work order by KEPCO E&C at the beginning of task 6.

- The work order specifies the time, duration and methodologies for task 6 with mutual agreement between Contractor and KEPCO E&C.

3. Methods of Performance

A. Domain of Responsibility

- **KEPCO E&C**
 - Provides mutual agreed information so that the Contractor could perform the tasks.
 - **Contractor**
 - Provides the consulting services that are defined in Task 1 through Task 6
 - Provides the deliverables to KEPCO E&C as defined in Section B. Deliverables, below
 - Takes part in 4 technical meetings delineated in below.
 - **Technical meeting**
 - Kick off meeting(1st technical meeting) will be held in Contractor's office within 3 working days with responsible people participated.
 - 2nd technical meeting on task 1 and 3 will be held in Contractor's office within 15 working days with responsible people participated.
 - 3rd technical meeting on task 2 will be held in Contractor's office within 5 working days with responsible people participated.
 - 4th technical meeting on support for task 5 will be held in KEPCO E&C's office or other places (Daejeon, Gyeongju) in Korea with 5 working days.
- * Meetings can be substituted by video conference system due to COVID-19.

B. Deliverables

No	Activities/Deliverables	Submittal Due Date *	Remarks**
1	<ul style="list-style-type: none"> • 25EA equipment seismic fragilities submittal (Task 1) • PUPCE draft calculation submittal (Task 3) 	T0 + 5 months	All final calculations and reports shall incorporate KEPCO E&C's comments and its resolutions by Contractor
2	<ul style="list-style-type: none"> • Submittal of final PUPCE calculation, analysis model, input & output electronic files, and all other auxiliaries files needed for analysis (Task 3) 	T0 + 9 months	
3	<ul style="list-style-type: none"> • Final PUPCE report submittal (Task 3) 	T0 + 10 months	
4	<ul style="list-style-type: none"> • Remained 25EA equipment seismic fragilities submittal (Task 1) 	T0 + 9 months	

	<ul style="list-style-type: none"> • Submittal of review results for 5EA RCS equipment fragilities calculation done by KEPCO E&C (Task 1) • 2EA representative calculations submittal to provide for KHNP (Task 1) 		
5	<ul style="list-style-type: none"> • Submittal of a review report for plant response analysis done by KEPCO E&C (Task 2) • Submittal of a final report for 50EA equipment seismic fragilities (task 1) • Submittal of a final seismic walkdown report (Task 4, schedule to be flexible due to site condition) 	T0 + 10 months (Task 4 shall be performed in accordance with each work order.)	
6	<ul style="list-style-type: none"> • Licensing(RAI) support (Task 5) 	In accordance with each work order	

*T0 : Execution Date

**Commentary duration by KEPCO E&C will not exceed 2 months. Due to commentary duration, the Contractor shall submit draft final report/calculation to KEPCO E&C 2 months before Submittal Due Date of each final report/calculation.

4. Schedule

Completion date of the work activities is 2023.3.31 from the Execution Date. Details of the schedule and milestones are delineated in the following Table. Detailed time schedule can be adjusted during the kick-off technical meeting through discussion between the Contractor and KEPCO E&C.

Tasks	Month after Execution Date											
	1~3			4~6			7~10			11~'23.3.31		
Kick-off Meeting	■											
Task 1	■	■	■	■	■	■	■	■	■			
2 nd and 3 rd Technical meeting								■	■			
Task 2							■	■	■			
Task 3	■	■	■	■	■	■	■	■	■			
Task 4							■	■	■	■		
Task 5 – RAI support and 4 th Technical Meeting										■	■	■

* The above schedule including technical meetings can be changed with a mutual agreement.

* Schedule of task 6 will be agreed considering EPRI's (Electric Power Research Institute) SQUG program schedule.

Attachment

Work Order Form

<p>To :</p> <p>I, the undersigned, hereby authorize this work order under which you shall provide the required Services described below in accordance with the terms and conditions of the agreement.</p> <p>work order No. : _____ Issue Date : _____</p>				
M/H Budget	- Technical fellow : __M/H - Principal Engineer : __M/H - Senior Engineer : __M/H - Lead Engineer : __M/H - Staff Engineer : __M/H - Total : __M/H *Actual costs are limited to each budget shown in contract price.			Assignment Start Date :
				Assignment Period :
Scope of Work :				
Delivery Requirement :				
Any Other Special Requirement :				
Other Cost (Ex. Travel expense) :				
Name(s) of Personnel to Carry Out the Work :				
References :		Initiated by KEPCO E&C Discipline : Name : Signature :		Coordination
				Position Name Signature
Agreed to by Contractor PM				
_____ (Name) (Signature) (Date)				
Authorized by KEPCO E&C PM				
_____ (Name) (Signature) (Date)				