

붙임2.

# 국외기술자문 내역서

[스트레스테스트 4분야에 대한 국외기술자문]

2018. 04.



## **PART.1 Scope of Services**

The scope of services to be performed by the Contractor under this agreement includes the followings.

### **1.1 Technical consultation for the analysis of severe accident phenomena for CANDU type using ISAAC code.**

- Task 1: General description of severe accident phenomena for CANDU
  - Task 1 will comprise general description of severe accident phenomena for CANDU. The general description will include all significant severe accident features such as severe accident regulations, methodology, progressions, sequences of events and etc. The general description should be categorized below :
    - Summary of the severe accident phenomena for CANDU
    - Summary of analysis methodology for severe accident for CANDU
    - Summary of the severe accident progression for CANDU
    - Summary of the sequence of major events for CANDU
    - Summary of the sequence of specific events for CANDU
    - Summary of the severe accident prevention/mitigation features for CANDU
- Task 2: Selection of Representative Sequences for Severe Accident for CANDU
  - Task 2 will comprise and prepare a report documenting the bases of sequences selected that based on PRA(Probabilistic Safety Analysis) dominant sequences and based on Deterministic dominant sequences
- Task 3: Severe Accident Analysis Report for CANDU
  - The base code for the analysis will be ISAAC 4.03+. FAI will develop input files for 15 representative sequences and will perform ISAAC analysis for both MCCI and hydrogen evaluation without any uncertainty or sensitivity study. The following are specific tasks to be performed:
    - Prepare input files for 15 representative sequences:
      - ◆ In this task, FAI will develop, test, and debug 15 input files for dominant PSA sequences and deterministic sequences.
    - Perform MAAP5 PWR code and ISAAC runs to calculate representative FCHF:

- ◆ The MAAP5 PWR code has detailed coolability model (bulk cooling, melt eruption, water ingress) and more advanced corium pool model. On the other hand, ISAAC has only one parametric value for the flat plate CHF multiplier FCHF. Using ISAAC's corium flows and calandria vault conditions as boundary conditions, the MAAP 5 PWR code will be used in benchmark mode to calculate the concrete erosion depth. ISAAC's FCHF value will be adjusted to provide a similar concrete erosion depth.
- Perform ISAAC runs and review of results for Hydrogen generation, release and combustion:
  - ◆ In this task, ISAAC results will be examined for hydrogen generation, transport, and distribution.
- Molten Core-Concrete Interactions (MCCI):
  - ◆ Based on ISAAC results, MCCI results will be examined.
- Prevention of overpressure in Containment Building:
  - ◆ Without any operation actions or mitigation, it is expected that the containment pressurization will occur in most cases. In this task, any available mitigative features plus operator actions will be considered to reduce or prevent the containment over-pressurization.

○ Task 4 : Documentation of Results

- This task includes preparation of a draft report and a final report documenting input files and results. In addition, QA review of all input files and results will be performed. The final report will also be prepared after addressing review comments from KEPCO-E&C.

○ Task 5 : Licensing Support

- The Korean Nuclear Regulator (KINS) can make consequential Requests for Additional Information (RAIs). To address these RAIs, technical support for RAIs will be provided on a Time and Materials (T&M) basis planned from 2nd quarter of 2019 through the 4th quarter of 2019.

## 1.2 Technical Meeting with KEPCO E&C and Regulatory

- Kick-off meeting: Approximately one month after the project has commenced, the

contractor will host a technical meeting with KEPCO E&C at contractor's office. The topics to be discussed during the meeting include overall approach of the project and project schedule.

- 2<sup>nd</sup> meeting: The contractor will arrange the 2<sup>nd</sup> technical meeting at FAI office after the issue of the draft report. Following topics can be discussed : Preliminary results of hydrogen generation, release and combustion analysis.
  - Preliminary results of hydrogen generation, release and combustion analysis.
  - Preliminary results of prevention of overpressure in containment building.
  - Preliminary results of Molten Core-Concrete Interaction(MCCI) analysis

FAI will prepare meeting minutes that include technical discussion with engineers made during the meeting with action items if any, which will be in the final consulting reports later. Draft minutes will be reviewed by the engineers and comments resolved prior to the end of the meeting.

## **PART. 2 Methods of Performance**

### **2.1 Methods of Performance**

- The contractor will start the consulting service in accordance with the schedule shown in Section 2.3, immediately after signing of the Contract Agreement.
- Basic modeling data for analysis will be provided by KEPCO-E&C. Data will be requested throughout the project as needed.
- Analysis results will be provided by contractor before the 2nd technical meeting. During the technical meeting, the Contractor's comments and KEPCO E&C's questions will be discussed to draw technical resolutions. After completion of consulting services, the final consulting report will be prepared by the Contractor and sent to KEPCO E&C via express mail.

- The Contractor shall keep confidential all the data and information provided by KEPCO E&C, and shall not divulge them to any third parties.
- Performance of services may be conditional on obtaining necessary export approvals or licenses. FAI will not be liable for failure to perform or delay in performing its obligations under this Agreement if the failure or delay is caused by applicable import or export control sanctions, laws, regulations, or requirements. All data to be provided by KEPCO E&C shall be provided by KEPCO E&C directly to the designated FAI engineers located at the FAI United States office locations.

## 2.2 Deliverables

A draft version of each deliverable will be provided to KEPCO-E&C for one (1) consolidated round of review and comments. Westinghouse will incorporate comment resolution as appropriate and provide KEPCO-E&C with a final deliverable. The deliverables for this proposal include two reports:

No	Deliverables	Date of Submittal
1	Report #1 for a general description of severe accident for CANDU (1.1, Task 1)	Signing date + 4 month
2	Report #2 describing the following: <ul style="list-style-type: none"> <li>■ Basis of representative severe accident sequences (1.1 Task 2)</li> <li>■ Input file and results description <ul style="list-style-type: none"> <li>◆ FCHF selection</li> <li>◆ Results of hydrogen evaluation</li> <li>◆ Results of MCCI</li> <li>◆ Results of prevention of over-pressure in containment</li> </ul> </li> </ul>	30, May., 2019
3	Electronic file of all input and output files	30, May., 2019

## 2.3 Contract Period and Consulting Schedule

The Contract Period shall be from the effective date of the agreement to 28, February, 2020.

The purchase order will be provided by June 2018, the consulting schedule will be as follows:

Tasks	M/ H	2018/ Quarter						2019/ Quarter								2020/ Quarter					
		2		3		4		1		2		3		4		1					
Task1 General description of severe accident phenomena for CANDU	FAI																				
Task2 Selection of Representative Severe Accident Cases for CANDU	FAI																				
Task3 Severe Accident Analysis Report for CANDU	FAI																				
Task4 Documentation of Results	FAI																				
Task5 Licensing Support	FAI																				
Total	FAI																				

### **PART.3 Compensation and Terms**

#### **3.1 Fixed Portion**

Task #	Task Description	Position Assigned	Hourly Rate	Man- Hour	Amount
Task 1 GENERAL DESCRIPTION OF SA FOR CANDU	Report for General Description of Severe Accident Phenomena	Consultant (Dr. Henry)	325	100	32500
		Advisory Eng. (ENGADV)	275	20	5500
		Administrative (ADM)	90	16	1440
	Total man hours and cost			136	39440

Task 2 SELECTION OF REPRESENTATIVE SEQUENCES	Documenting the basis of representative severe accident sequences for CANDU	Advisory Eng. (ENGADV)	275	20	5500
		Senior Engineer 2 (ENGSR2)	225	40	9000
	Total man hours and cost			60	14500
Task 3 SEVERE ACCIDENT ANALYSIS REPORT(15 REPRESENTATIVE SEQUENCES FOR BOTH MCCIU/H2 EVALUATION WITHOUT ANY SENSITIVITY/UNCERT AINTY STUDY)	Prepare input files for 15 representative sequences	Advisory Eng. (ENGADV)	275	12	3300
		Senior Engineer 2 (ENGSR2)	225	60	13500
	Hydrogen Generation, Release, and Combustion	Advisory Eng. (ENGADV)	275	20	5500
		Senior Engineer 2 (ENGSR2)	225	60	13500
	Prevention of Over-pressure in Containment	Advisory Eng. (ENGADV)	275	20	5500
		Senior Engineer 2 (ENGSR2)	225	40	9000
	MCCI (FCHF evaluation using MAAP5 PWR code)	Advisory Eng. (ENGADV)	275	20	5500
		Senior Engineer 2	225	40	9000
	MCCI Evaluation using adjusted FCHF	Senior Engineer 2	225	40	9000
	Total man hours and cost			312	73800
Task 4 DOCUMENTATION OF RESULTS	QA Review of Inputs and Results	Senior Engineer 2	225	60	13500
	Draft Report of Tasks 2 and 3	Senior Engineer 2	225	60	13500
	Addressing Review comments from KEPCO-	Senior Engineer 2	225	40	9000

	E&C				
	Final Report	Senior Engineer 2	225	40	9000
	Total man hours and cost			200	45000
TECHNICAL MEETINGS	Two Meetings at FAI	Advisory Eng. (ENGADV)	275	48	13200
		Senior Engineer 2	225	60	13500
	Total man hours and cost			108	26700
TOTAL				816	199440*
Task 5 - Licensing Support	Time and material based on the individual rates				T&M

\* The Positions are classified in accordance with the work experience. (Engineer I – more than 1 year, Senior engineer I – more than 5years, Senior Engineer II – more than 10 years, Senior Tech Adv I – more than 20 years)

### 3.2 Time and Material Portion

This task will support KEPCO-E&C for any RAI questions or any interaction with licensing body (Section 1.1, Task 5). RAI question type and working hours will be determined from their difficulty and the complexity. Those items will be requested to the Contractor on the reimbursable basis. The capped price will be \$55,000 and the following rates will be used for this reimbursable portion for RAI support service:

<b>Staff/Category (4/1/2018 to 3/31/2019)</b>	<b>Hourly Rate (\$/hr.)</b>
Advisory Engineer (ENGADV)	\$275
Senior Engineer 2 (ENGS2)	\$225
Senior Engineer (ENGSNR)	\$195
Engineer (ENGINR)	\$160
Drafting (TECHNI)	\$145
Administrative (ADM)	\$90
<b>Staff/Category (4/1/2019 to 2/28/2020)</b>	<b>Hourly Rate (\$/hr.)</b>
Advisory Engineer (ENGADV)	\$285
Senior Engineer 2 (ENGS2)	\$230

Senior Engineer (ENGSNR)	\$200
Engineer (ENGINR)	\$165
Drafting (TECHNI)	\$150
Administrative (ADM)	\$95

Total price is approximately estimated based on the average hourly rate and Man-Hour as below.

Staff Category	Hourly Rate* (\$/hr.)	Avg. Rate (\$/hr)	Approx. total hours	Approx. Total (\$)
Advisory Engineer (ENGADV)	\$285	\$188	292	55,000
Senior Engineer 2 (ENGSR2)	\$230			
Senior Engineer (ENGSNR)	\$200			
Engineer (ENGINR)	\$165			
Drafting (TECHNI)	\$150			
Administrative (ADM)	\$95			

\*) Hourly rate proposed for 2019.04.01~2020.02.28 is used in the approximate estimation because RAI support service task will be conducted until 2020 according to Consulting Schedule in Section 2.3.

For RAI support (questions from KINS or any additional runs required), FAI and KEPCO-E&C will discuss how many hours are needed to address each RAI. Once the required man-hours and associated rates are mutually agreed, KEPCO-E&C can issue a work-order. FAI will provide timely support to address the work-order.

### 3.3 Payment Schedule

Activity	Amount, USD	Schedule
At completion of delivery of mid report	50% of fixed portion	50% of contract amount paid within 30days after receipt of mid report and invoice
At completion of delivery and acceptance of final report	50% of fixed portion	50% of contract amount paid within 30days after receipt and acceptance of final report and invoice
Licensing Support	-	100% of contract amount paid within 30days after receipt of report based on

		one work order
Total	\$199,440	