Technical Consultation on Analysis of Hydrogen Leakage, Dispersion, and Explosion in Hydrogen Production Facility with NPP

07.2023

한국전력기술주식회사
KEPCO ENGINEERING & CONSTRUCTION COMPANY, INC

1.0 PURPOSE

KEPCO E&C is considering a nuclear power plant linkage design necessary for producing nuclear clean hydrogen through the installation of hydrogen production facilities.

However, hydrogen gas must meet the U.S. NRC licensing requirement of RG1.91, which describes safe separation distances as combustible and explosive materials.

Therefore, we would like to conduct this Contract to develop a model that can satisfy the requirements through reasonable analysis in the event of an event in a hydrogen production facility. In addition, this can be used not only in nuclear hydrogen but also in general hydrogen facilities.

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

2.0 TECHNICAL SCOPE OF WORK

Contractor shall provide the following engineering services to KEPCO E&C as described in the following tasks:

Task 1: Development of methodology for analysis of jet release from high-pressure hydrogen containers (or piping)

i. Analysis of hydrogen release rate considering the leakage angle (0~90 degree)

ii. Analysis dispersion from the release point

iii. Prediction of hydrogen concentration distribution based on Cartesian coordinate system (e.g., C = C(x,y,z))

iv. Development of methodology for puff and plume release scenarios

(Puff : Instant release, Plume : Continuous leak)

v. Dispersion effects caused by ground reflection or collision of hydrogen and hydrogen-air mixture

vi. Consideration of meteorological conditions such as wind speed(1.5m/s), atmospheric stability(F) and anterior wall (as a function of distance).

vii. Provide the explosive or/and flammable mass according to the distribution sizes (e.g., x,y,z) and distribution for the hydrogen concentration(e.g., 4%~75%) including the reasonable validity.

viii. Prediction of maximum hydrogen concentration as a function of distance from an infinite or finite source

1. Determination of flammable or explosive mass (e.g., mass corresponding to the flammability limits (e.g., 4~75%))
2. To develop a methodology that is realistic and simple, it is important to avoid overly

conservative assumptions or approaches. Instead, the methodology should consider the following physical properties and dispersion behavior of hydrogen gas:

- The mixing of hydrogen and air is influenced by meteorological conditions such as wind speed and atmospheric stability.
- Hydrogen gas is a light material that rises with a large buoyancy force in NTP at speeds ranging from 1.2 to 9 m/s.[1].
- The flammability limits of hydrogen are 4 to 75%, but the explosive limits are 18 to 59%. Therefore, if ignition occurs at the lower flammable limit (LFL) of 4%, it is necessary to consider the possibility of transitioning to detonation accompanied by a blast wave.

Task 2: Determination of explosion overpressure prediction methodology.

i. Determination and basis for predicting overpressure caused by hydrogen explosion
    1. Examination of the applicability of experimental methodologies such as TNT(or ME, and BST) in terms of NPP licensing.
    2. Determination and basis for predicting overpressure due to puff and plume releases
    3. Development of overpressure curves as a function of distance from the overpressure origin

ii. Determination and basis for setting the overpressure origin
    1. Determination and basis for setting the overpressure origin (e.g., LFL, LEL, centroid or others) including the reasonable validity.
    2. Setting the overpressure origin according to the location of the ignition source (ground or aerial ignition)

iii. Provide the basis for the decision as above (reference paper, etc.).

Task 3: Technical Meeting

- Video conference for Contract on the details and purpose of Contract and/or results

Task 4: Documentation

i. Write technical reports for Task 1, 2, and 3.

ii. Review and comment resolution

[1] National Aeronautics and Space Administration (NASA). Safety Standard for Hydrogen and Hydrogen Systems: Guidelines for Hydrogen System Design, Materials Selection, Operations, Storage, and Transportation, pp.2-21, July 25, 2005.

3.0 METHOD OF PERFORMANCE

<u>Contract Schedule</u>

The Contract schedule for the basic tasks (Task 1 to 4) shall be carried out for 4(four) months from the Execution Date (the "Contract Performance Period") of the Contract, as follow.

Tasks	Schedule			
	Execution Date +1M	Execution Date +2M	Execution Date +3M	Execution Date +4M
Task 1 : Development of methodology for analysis of jet release from high-pressure hydrogen containers (or piping)				
Task 2 – Determination of explosion overpressure prediction methodology.				
Task 3 – Technical Meeting	`			
Task 4 – Documentation				

<u>Method of Performance</u>

1) After the Contract date, the Contractor must start the service according to the detailed schedule of 3.0 METHOD OF PERFORMANCE, and KEPCO E&C provides related detailed information for the performance of the work of 2.0 TECHNICAL SCOPE OF WORK - Task 1&2 if necessary. The Contract shall be ended by 4 months from the Execution Date.

2) The Contractor shall comply with the security of all information and data provided by KEPCO E&C and shall not provide it to other third parties.

<u>Deliverables</u>

- Preliminary Report shall be provided by 3 weeks before the end of the Contract Performance Period.

- Final Report shall be provided by before the end of the Contract Performance Period.