Safety Analysis of Aqueous Formate Solution based Large Scale Hydrogen Storage

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Hydrogen is widely recognized as a key energy carrier for the transition toward a decarbonized economy. However, its use relies on production, distribution, and storage methods that are both sustainable and safe. Traditional storage techniques, based on compressed or liquefied hydrogen, present critical issues due to the intrinsic properties of the gas and the extreme conditions required for its preservation. An alternative solution for both stationary and mobile applications is the storage of hydrogen in aqueous solutions of formates. In the presence of a suitable palladium-based catalyst, these solutions can release hydrogen under near-ambient temperature and pressure conditions (50–90 °C and 2–10 bar), generating aqueous solutions of bicarbonates. Although this storage system is safer compared to other hydrogen storage technologies, it is not entirely risk-free [1]. In particular, the accidental release of stored gas may lead to the formation of flammable clouds, posing a potential hazard to facilities and surrounding areas. Previous studies have presented a quantitative risk assessment of small/medium scale hydrogen storage, providing the evaluation of consequences [1]. To support the development and industrial-scale deployment of this technology, it is necessary to extend the analysis to more realistic operating conditions, considering significantly larger hydrogen volumes. This work aims to further investigate the safety aspects of large-scale hydrogen storage by modelling the consequences of accidental releases of flammable substances using the PHAST software [2]. The scale effect was studied by varying the storage volume from 500 L to 5000 L. For 500 L of formate solution the 50% fatalities in terms of thermal flux in case of a jet fire extends from 11.9 m to 18.5 m, whereas for a compressed hydrogen tank it reaches 33.4 m (Fig. 1A). Moreover, the flammable concentration range has been found to be broader for compressed hydrogen than for the formate solution (Fig. 1B).

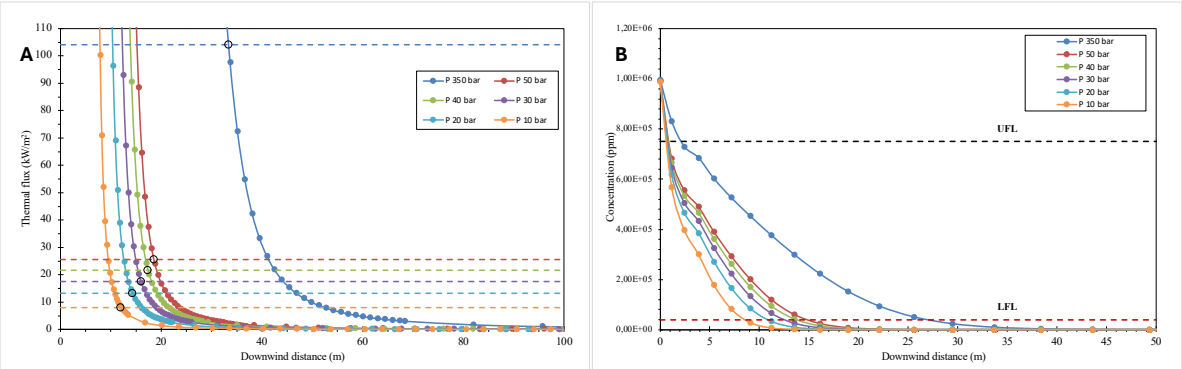

Fig. 1. A. Thermal flux as a function of distance from the jet fire release point. B. Hydrogen concentration versus distance from the release point under continuous release.

Keywords: hydrogen storage safety, formate-based hydrogen release, quantitative Risk Assessment

[1] Danilo Russo, Roberto Andreozzi, Marcella Calabrese, Raffaele Marotta, Almerinda Di Benedetto, Quantitative risk assessment of aqueous formate for hydrogen storage, International Journal of Hydrogen Energy 65 (2024) 421–427.

[2] https://www.dnv.com/software/services/plant/consequence-analysis