CFD Simulation and Risk Assessment of Hythane Release from Gas Pipelines: Natech Effects

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The use of hydrogen-based technologies requires a infrastructures for production, transportation, storage and distribution on a small, medium and large scale. At present, the main focus is on optimizing technical performance. However, the development of hydrogen infrastructure must first and foremost consider safety aspects. The development of safety policies and procedures is imperative to guide the development of small and medium scale H_2 storage technologies, systems and transportation infrastructure. As far as transportation/distribution is concerned, it should be examined whether it makes sense to supplement existing methane pipelines with H_2. In this case, the risks change significantly and heavily depend on the H_2/CH_4 ratio. The criteria for the compatibility of new and existing steel pipelines for hydrogen transportation are all included and discussed in a recognized international standard ASME B31.12[1]. RINA, a leading Italian company for international certifications, is currently in the process of verifying the compatibility of existing gas pipelines for hydrogen transportation. Although this standard is constantly being developed and updated, there are still some critical issues, mainly related to the pipe materials. However, in the short term, ASME Working Group B31.12 is using specific design factors to make system design more conservative until actual material test data is available and is encouraging risk analysis of retrofitted and hydrogen piping systems to further improve these factors [1]. In this study, computational fluid dynamics (CFD) simulations with a RANS approach are used to model the release and dispersion of hythane from gas pipelines, with a focus on risk assessment and the influence of natural hazards that trigger technological accidents (NaTech). The simulations provide a nuanced understanding of the complex dynamics responsible for the dispersion of hythane, taking into account factors such as wind patterns, atmospheric stability and terrain features. To take into account natural hazards, different vulnerability models for sismic, flooding and lightning events, already found in the literature or *ad-hoc* adapted for pipelines, will be used to assess the frequency of occurrence of pipeline damage related to natural events [2]. Using the vulnerability models, it will also be possible to identify the right type of damage (catastrophic rupture or hole) and understand the actual presence of a loss of containment. CFD simulations to assess the release and dispersion of mixtures are combined with the use of empirical models to quantify the results in the case of large-scale applications. Results will be also compared with that obtained in the case of application of empirical models also to model the dispersion. The study will evaluate the effectiveness of various preventative measures, including advanced monitoring systems, emergency response protocols and infrastructure modifications. Results will contribute to the development of proactive measures and strategies that will ultimately promote the safety, sustainability and resilience of gas pipeline systems in the face of unforeseen natural disasters.

1. The American Society of Mechanical Engineers. *ASME B31.12 - Hydrogen Piping and Pipelines*. *Asme International* vol. 2011 (2014).

2. Cozzani, V. *et al.* Quantitative assessment of domino and NaTech scenarios in complex industrial areas. *J. Loss Prev. Process Ind.* **28**, 10–22 (2014).

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