# Beyond NaTECH Risk: Safety and Resilience in Hythane Transport Infrastructure

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***Highlights***

- Natural events can be responsible of several industrial accidents.
- Hythane reduces $CO_2$ emissions.
- Hythane's flammable mass is limited compared to the total mass dispersed, due to high diffusivity.

## 1. Introduction

A technological accident caused by a natural disaster is known as NaTECH (Natural hazard triggering technological disasters). Today, such events are a topic of great interest and concern due to the increase in the intensity of weather-related phenomena, caused mainly by climate change. The Multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate (RETURN) project aims to improve the entire disaster risk management cycle. The present study is focused on a NaTECH risk analysis of Hythane transport infrastructure.
Hythane is a hydrogen-enriched methane mixture that is used as a potential bridge solution to reduce $CO_2$ emissions, to meet the requirements of progressive decarbonisation. Several immediate benefits were obtained from the use of this mixture in terms of emissions and the investment associated with the development of suitable infrastructure, significantly lower than for pure hydrogen. Therefore, the use of hydrogen in the form of Hythane could be the perfect solution for the near future. Nevertheless, the challenges related to the use of Hythane should not be underestimated, namely economic viability compared to the use of pure methane, as well as safe storage and transport.
The use of Hythane in transport and distribution networks, while tempting, must be properly weighed up by first conducting studies on the safety of the mixture and comparing it with the use of methane alone, but also on the compatibility of Hythane with current infrastructures.

## 2. Methods

A quantitative risk analysis (QRA) of Hythane pipelines was performed, considering different mixtures at different $CH_4/H_2$ ratio, using a specific framework for NaTECH scenarios [1]. Earthquakes, floods and lightning strikes were assessed as natural events and loss of containment (LOC) triggers. Specific vulnerability models from the literature were used to assess the frequency of pipeline damage associated with natural events [2]. These models were also used to determine the correct type of damage (catastrophic rupture or hole) and to understand the actual presence of a LOC. After assessing the frequency of occurrence of the LOC, the event tree analysis (ETA) was developed to assess the frequency of occurrence of the consequences.
The consequences were predicted by coupling empirical models and computational fluid dynamics (CFD) simulations, based on the Reynolds Averaged Navier-Stokes (RANS) approach. The empirical methods as well as the simulations take into account factors such as wind speed, atmospheric stability, ground conditions and release height.

## 3. Results and discussion

The probability assessment of LOC occurrence for the flooding event showed no probability of failure associated with a mechanical fault, even under severe conditions, resulting in a zero value for the LOC frequency and thus concluding the analysis. In the event of a seismic event, the ETA results in atmospheric dispersion, vapour cloud explosion (VCE), and jet fire. In the case of a lightning strike, only jet fire occurs as a flammable material is released with a consistent probability of instantaneous ignition.

The consequences for the jet fire were calculated by means of empirical models that relate the radiant heat flux received at different distances from the point source for different $CH_4/H_2$ ratios. The results show that the extent of the iso-risk zone for both seismic and lightning events increases as the mole fraction of hydrogen in the Hythane increases.

Preliminary CFD results of the release and propagation model are shown in Fig. 1. The mass of flammable Hythane relative to the total mass released at t=60s is limited due to the low flow rate and the high diffusivity of the mixture, which leads to rapid mixing of the Hythane with the air. The CFD results were compared to the results obtained by empirical models of dispersion, suggesting that CFD models are quite more reliable in predicting dispersion, on increasing the $H_2$ content.

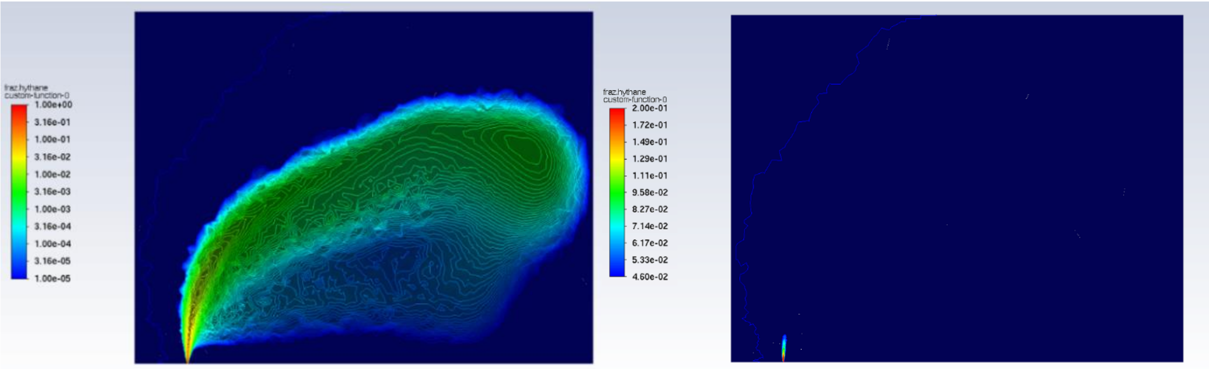


**Figure 1.** Hythane ($H_2/CH_4$= 0.25) dispersion in terms of molar fraction (left) and in terms of molar fraction within the flammability limits (right).

## 4. Conclusions

To optimise the use of Hythane in transport infrastructure, different $CH_4/H_2$ ratios that increase the hydrogen content of the mixture need to be investigated both empirically and through CFD simulations. The knowledge gained will help in the development of proactive measures, protocols and strategies that increase the safety and resilience of pipelines against unforeseen natural disasters. Therefore, a thorough assessment of the safety, transport, and compatibility of Hythane with existing infrastructures is required before it can be widely deployed.

## References

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[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).

***Keywords***

NaTECH; Risk analysis; CFD simulations; Hythane.

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