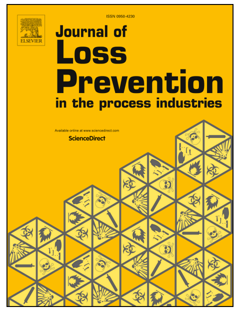

Experimental study and modelling of the consequences of small leaks on buried transmission gas pipeline

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Experimental study and modelling of the consequences of small leaks on buried transmission gas pipeline

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Abstract

Operators of gas infrastructures, such as gas pipelines or gas storages, have to ensure safety for employees as well as third parties in the surroundings of installations. For this purpose, risk analysis are performed to assess the level of risk for a given installation. Safety partnerships have been launched to carry out experimental and theoretical studies, for instance to assess the outcome of a leak occurring on a buried pipeline. A previous work performed by ENGIE, Air Liquide, TIGF, National Grid and Petrobras has focused on a nearly-real scale, simulated leak on a pipeline at 1 m depth with a 12 mm diameter breach. However, the number of tests was not sufficiently high to be able to assess the influence of all parameters such as leak diameter, pressure, pipe depth, soil type, water content etc. Different phenomena like gas migration in the soil, uplift or crater formation may occur. The objectives of this work were to experimentally study the influence of these different parameters on the release outcome. Small scale experiments have been conducted and more than a hundred trials have led to identify empirical transitions between the different outcomes. Moreover, new phenomena occurring in the ground have been highlighted, such as cavities formation, where gas may accumulate, or also, the drying and the freezing of the soil surrounding the leak.

Keywords: leak, risk assessment, gas transportation, natural gas, crater, gas migration

1. Introduction

Operators of gas infrastructures such as gas pipelines, gas storages, and regasification terminals have to ensure safety for employees as well as third parties in the surroundings of installations. In order to comply with this commitment (which is a regulatory requirement in many countries), risk analysis are performed to assess the level of risk for a given installation. The general approach of these analyses is to identify hazardous scenarios and to estimate the risk by quantifying both the frequency of hazardous phenomena, the intensity of the phenomena (for example heat flux for fire and overpressure after ignition) and the vulnerability of nearby people and equipment. Since the development of natural gas in the 1950s, ENGIE has, among other, contributed to major experimental and theoretical studies in the framework of safety partnerships. This work has enabled the gas industry to enhance the knowledge and the modeling of the physical phenomena linked to high pressure natural gas releases. According to the EGIG database (2015), between 1970 and 2013, in Europe, 1249 incidents leading to leakage were reported for the gas transmission network, 56 were ignited, and less than 7 resulted in fatalities. Similarly, for underground gas storage, 14 massive leakages were reported in the various databases and 4 were ignited. Those figures show that accidents involving ignited massive releases in transportation and storage installation are relatively rare.

In 2014, ENGIE, Air Liquide, TIGF, National Grid and Petrobras undertook a Joint Industrial Program (JIP) named "CRATER" (Houssin-Agbomson et al.) with the aim of improving the understanding of small leaks (below 12 mm of release diameter) on buried gas pipelines. Indeed, studies on this subject are rare and generally focus on large gas leaks (more than 12 mm of release diameter) (Acton and Hankinson, 2000, Allason et al., 2012, Gant, 2012). An experimental campaign was therefore conducted by INERIS, in their experimental site of Verneuil-en-Halatte (France). The study, carried out on a nearly-real scale, simulated a leak on a pipeline with a 12 mm diameter breach. Three different types of phenomena were identified from the experiments: i) migration of gas in the soil, ii) uplift and cracking of the soil, and iii) crater formation. The occurrence of these phenomena varied according to the type of soil (sandy or clay soil, Holtz and Kovacs, 1981), pipeline pressure, water