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Accident survey of heavy rainfall induced landslide-triggered events on oil and gas pipelines in Colombia

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Introduction

In mountainous regions, mainly in tropical areas affected by heavy rainfall periods, landslides represent some of the most frequent natural hazards threatening oil and gas transmission pipelines[1]. This is the case of Colombia, where this type of infrastructure is vulnerable to these events that could become more frequent and more intense due to climate change.

Landslides can generate permanent ground displacement on the pipeline's right of way (ROW), imposing loads that can generate a catastrophic failure, leading to loss of containment (LoC) of hazardous materials. These natural hazard triggered technological accidents are known as Natechs. Natechs can cause long-term environmental impacts, affect nearby communities threatening their lives and infrastructure, and cause gas service disruption, even affecting oil and gas availability, leading to vital impacts on wide areas[2]. The aim of this study is to analyze past accidents in order to understand the trends and dynamics of this kind of accidents based on the analysis of an accident database.

Past studies

A few works have investigated past accidents involving pipelines. One study [3] identified accidents in several databases around the world, involving the explosion of natural gas pipelines leading to crater formation, to study the influence of pipeline parameters on the crater and how can this affect parallel pipelines. Other previous work [4] studied the influence of various natural hazards in pipeline accidents on Europe and the US databases and accidents reports. Nevertheless, an analysis of landslide impacts on pipelines was not found.

Methodology

Data for this study was retrieved from accidents reported to the National Agency for Environmental Licenses (ANLA) database in Colombia (a mountainous country with pipelines all over the territory) complimented with information from news, government and industry reports. ANLA's database contained nearly 10300 entries registered between 2000 to 2022, related with any LoC events associated to the mining and energy sectors in the country. The database has evolved due to changes in reporting requirements, resulting in different collected information, and influencing the number of related reports per year. This represented a challenge for the consolidation of the database into one file for keyword based search. Another interesting challenge concerning the keyword search was due to the differences in regional dialects used to enter the event descriptions in the database.

To perform the analysis, first it was necessary to complete the missing information in the accidents reported in the database. This required a search for additional information sources (e.g., news reports, government and industry reports) and extracting the needed information.

Results

The present work addressed the analysis of the identified events that were gathered from the Colombian national database. The analysis showed that there were 250 Natechs in the period studied (around 2.5% of the total events). Of these Natechs, 116 involved oil and gas transmission pipelines, and of

these, 86 were due to landslides. Landslide was found to be the most common natural hazard causing damage to pipelines, followed by heavy rainfalls and floods.

Regarding the consequences, it was found that the substance most frequently involved is natural gas, and that around 2.4% of these events triggered important fires and explosions. Another finding corresponds to 37% of the events generating environmental contamination (sometimes affecting the availability of drinking water). During the studied period, there were 31 reported deaths, at least 86 injured people and 650 neighboring homes affected. As for indirect consequences, 60% of the events led to the interruption of natural gas service in several municipalities and fuel availability, increasing the livelihood cost.

Regarding the pipeline characteristics, the incidence of events was found higher in newer and smaller diameter pipelines, highlighting the importance of understanding if this is due to higher exposure or vulnerability, which would necessarily require the revision of construction standards, building codes and maintenance practices. Some pipelines were affected on more than one occasion by this type of Natech events, pointing to the importance of reviewing the risk management measures being implemented.

The analysis of past events led to a better understanding of the chain of events, showed the importance of landslides as a threat to hydrocarbon transmission pipelines, and helped to identify direct and indirect impacts on the environment and surrounding communities and environment. It also emphasized the importance of documenting lessons and communicating them to stakeholders in the territory in accordance with the guiding principles of the Disaster Risk Management Act in the country. These identified trends are a useful tool for industrial operators and government entities decision making processes, to contribute to the development of risk reduction measures and risk management policies.

The results of this study are in agreement with previous ones that found that the most common natural event related to pipeline Natech was landslides. All these landslides were caused by heavy rainfalls.

Conclusions

The analysis of past accidents has provided an overview of the problem, and permitted the identification of accident trends and lessons. The analysis was restricted by the limited relevant entries and the missing information. However it provided a general overview of some factors influencing the event occurrence and types of consequences. The results can support the risk assessment of this type of threat to communities living in the vicinity of oil and gas transmission pipelines subject to rain-induced landslides.

References

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