Development of Landslide-triggered Scenarios on Oil and Gas Pipelines for Risk Assessment

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The intricate interactions between natural hazards and industrial facilities handling hazardous materials, have contributed largely to exacerbate accidental impacts on communities and the environment, particularly in urban areas. Earthquakes, tsunamis, floods and landslides, among other hazards, have affected industrial facilities around the world, causing loss of containment events, such as fires, explosions, and oil spills resulting in huge economic and environmental damage. The frequency of these conjoint natural and technological hazards (known as Natech) is about 3-7% annually in chemical accident databases in the United States, Europe and Japan [1].

In mountainous regions all over the world, particularly in tropical areas affected by heavy rainfall periods, landslides represent some of the most frequent natural hazards leading to catastrophic events [2]. This is the case of Colombia and some other countries in Latin America, where industrial facilities such as oil and gas transmission pipelines are vulnerable to these extreme events, that could become more frequent and more intense due to climate change.

Landslide impacts to pipelines often result in large leaks leading to casualties, major impacts to the environment, and long periods of service disruption, causing extensive damage every year [2]. The related hazards are complex, and they require detailed risk assessments, but they require detailed information about the pipeline and the environment, and this could constitute a difficult task in the process. Risk assessment process has been implemented in the last decades in oil and gas industries and, more recently in some countries, Natech specific regulations for risk assessment are being put into effect. However, there is still a lot to be done in terms of raising awareness and including Natech scenarios on these assessments [3].

In the last decades, some works aimed at the development of risk analysis and assessment methodologies, considering fixed facilities as critical equipment and the impacts of natural events such as earthquakes [4], flooding [5] and lately even lightning have been proposed [6]. Nevertheless, a Natech risk assessment methodology to consider landslide impacts on oil and gas transmission pipelines, is still needed.

As mentioned in OECD previous workshops [7], developing specific guidelines is still needed to achieve Natech risk reduction. When it comes to Natech, the uncertainties are high for both the natural and the technological event occurrence and intensity. One way to deal with this difficulty in the assessment process, is to build well-defined scenarios. The present work addresses the scenario identification for events triggered by landslides on pipelines, analysing past events, and is meant to be a milestone in the development of a Natech Risk Assessment framework, to support decision making and prioritizing of resources to manage risks.

Scenario identification: Analysis of past events

The analysis of past accidents was carried out using a database from Colombia (a mountainous country with pipelines all over the territory), and its National Agency for Environmental Licences (ANLA), to support the

identification of potential scenarios to be considered in the framework. This may be challenging, due to the information availability, and the required knowledge about failure modes, causes and consequences, environmental properties (soil, rainfall among others), pipelines properties (operation, diameter, etc.) and vulnerability to landslides.

Considering the above, the first challenge for this work is the development of a tool to identify relevant scenarios for the latter analysis. The first step was to identify information sources, and as mentioned above, the ANLA database was chosen, because it is the national accidental database related to oil and gas pipelines in Colombia.

This database contains more than 8000 registers starting from 2000 up to 2020. To identify relevant entries, the first step was to filter the data, based on what was categorized as "Natural event". Those registers provided relevant keywords, to be used later for the identification of entries that were miscategorized but were actually caused by natural events, particularly landslides.

As a result, many events were identified as being caused by landslides. Every one of them was reviewed, and reviewed manually to be sure they were actually relevant. To analyse past events, the effort was set to identify failure modes, causes and consequences, relevant environmental and pipeline properties, and involved hazardous materials, defining some standard parameters for each event as follows:

- Pipeline properties: diameter, age.
- Environmental: soil type, rainfall patterns.
- Hazardous materials: gas, crude oil, gasoline.
- Consequences: impacts on communities, environment, infrastructure.

These identified values are the initial input for accident scenarios. This will be used later in the construction of bowties, as a part of the Natech risk assessment methodology, to contribute to the development of risk reduction measures, and risk management policies, to support industrial operators and government entities on their decision-making process, involving all stakeholders in the territory (communities, industrial facilities and government).

References

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