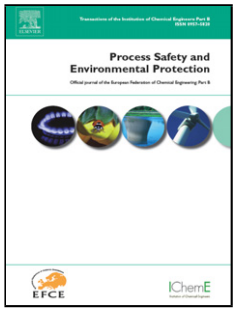

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Quantitative risk analysis on leakage failure of submarine oil and gas pipelines using Bayesian network

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Abstract: Submarine pipeline is the major transportation way of subsea oil and gas production. Due to the internal and external factor, the failure probability of submarine pipeline is increasing, which could lead to the spill accidents of oil and gas. Efficient risk analysis is vital for preventing and mitigating such potential accident. This paper presents a risk-based accident model to conduct quantitative risk analysis (QRA) for leakage failure of submarine pipeline. Firstly, we employ bow-tie method to model the causal relationship between pipeline leakage and potential accident scenarios. Subsequently, in order to overcome the difficulties of bow-tie in modeling uncertainties and conditional dependency, a Bayesian network model for pipeline leakage is developed through mapping from the former bow-tie. Meanwhile, an object-oriented Bayesian network that has a smaller and more clarified structure is also constructed by modularizing the primary Bayesian network. Eventually, the probability updating is implemented in risk analysis using Bayesian network when a new evidence or observation occurs, and an experience learning from accident precursor data is also conducted through Bayesian approach. The proposed accident model based on Bayesian network can provide a more case-specific and realistic analysis consequence compared to bow-tie method, since it could consider the common cause failures and conditional dependency in accident evolution process of pipeline leakage.

Key words: Quantitative risk analysis; leakage failure; submarine oil and gas pipeline; Bow-tie model; Bayesian network; accident precursor data

1. Introduction

The rising demand of energy accelerated the oil and gas exploration from ocean, countries like American, Canada, China or Japan have made exploration work in deep water area which reached 3000m water depth. Submarine pipeline is the major transportation way of subsea oil and gas after exploration and exploitation. However, because of scouring caused by current and wave, third-party damage and seaquake, or design defect, submarine pipelines has a relative high probability of leakage failure (Zhang et al. 2011). As per the UK Health and Safety Executive (HSE UK, 2011), there are about 1978 leakage incidents of oil and gas pipeline between 2001 and 2011 in the UK continental shelf. According to International Association Oil and Gas Producer (OGP UK, 2010), the allocation of failure mechanisms for submarine pipeline is as shown in Table 1. Once a leakage occurs, it may cause severe fire and explosion due to accident escalation, and pose a threat to human safety, environment, asset, and reputation (Fang et al. 2014). For instance, the leakage accidents of submarine pipeline of China Zhuhai and BP as shown in Fig. 1 are two representative examples.

Table 1 - Allocation of Failure Mechanisms for submarine pipelines (OGP UK, 2010).

Failure mechanism	Distribution
Corrosion	36%
Material	13%
External loads causing damage	38%
Construction damage	2%
Other	11%

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