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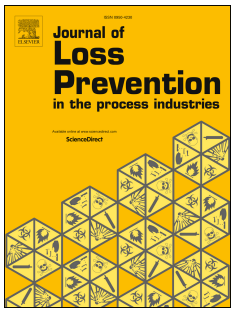

Historical analysis of U.S. onshore hazardous liquid pipeline accidents triggered by natural hazards

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Historical analysis of U.S. onshore hazardous liquid pipeline accidents triggered by natural hazards

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Abstract

Incidents at U.S. onshore hazardous liquid pipeline systems were analyzed with an emphasis on natural hazards. Incidents triggered by natural hazards (natechs) were identified by keyword-based data mining and expert review supplemented by various data sources. The analysis covered about 7,000 incidents in 1986–2012, 3800 of which were regarded as significant based on their consequences. 5.5% of all and 6.2% of the significant incidents were found to be natechs that resulted in a total hazardous substance release of 317,700 bbl. Although there is no trend in the long-term yearly occurrence of significant natechs, importance is found to be increasing due to the overall decreasing trend of the incidents. Meteorological hazards triggered 36% of the significant natechs, followed by geological and climatic hazards with 26% and 24%. While they occurred less frequently, hydrological hazards caused the highest amount of release which is about 102,000 bbl. The total economic cost of significant natechs was 597 million USD, corresponding to about 18% of all incident costs in the same period. More than 50% of this cost was due to meteorological hazards, mainly tropical cyclones. Natech vulnerabilities of the system parts vary notably with respect to natural hazard types. For some natural hazards damage is limited possibly due to implemented protection measures. The geographical distribution of the natechs indicated that they occurred more in some states, such as Texas, Oklahoma, and Louisiana. About 50% of the releases was to the ground, followed by water bodies with 28%. Significant consequences to human health were not observed although more than 20% of the incidents resulted in fires. In general, the study indicated that natural hazards are a non-negligible threat to the onshore hazardous liquid pipeline network in the U.S. It also highlighted problems such as underreporting of natural hazards as incident causes, data completeness, and explicit data limitations.

Keywords:
hazardous liquid, pipeline system, accident analysis, natural hazard, natech, PHMSA

1. Introduction

The pipeline network in the U.S. consists of 4.3 million km of pipes, more than 300,000 km of which is transporting hazardous liquids. The majority of hazardous liquids are crude oil, refined petroleum products, and other highly volatile liquids (HVLs) that are transported from producers and processors to industrial or commercial intermediate and end users mostly via large-diameter underground steel pipes (PHMSA, 2014c). Natural hazards, such as earthquakes, floods, and landslides, can be initiating events for accidents in pipeline systems with potentially adverse consequences on the population, the environment, and the economy including major supply chains. Accidents in which the natural and technological worlds collide, leading to the release of hazardous materials, fires or explosions are commonly referred to as natech accidents (Showalter and Myers, 1994; Krausmann et al., 2011a).

Numerous severe accidents bear testimony to the risk associated with natechs related to pipeline systems. The March 5, 1987 earthquake in Ecuador (Ms 6.9) caused the destruction of more than 40 km of the Trans-Ecuadorian oil pipeline due to massive debris flows following the earthquake. Approximately 100,000 bbl oil spilled to the environment and the loss of revenue during the five months required for repair was 800 million USD, equal to 80% of the total earthquake losses (NRC, 1991). The San Jacinto River flooding in Texas, U.S. in October 1994 led to the rupture of several pipelines by the flood waters. 34,500 bbl of crude oil and petroleum products were released into the river and ignited. Besides significant environmental damage, 547 people suffered inhalation problems and burns (NTSB, 1996b). The hurricanes in 2005 and 2008 that struck the Gulf of Mexico affected not only offshore but also onshore facilities and severely damaged the oil and gas industry in the region including pipeline operators due to strong winds, storm surge and flooding (DoE, 2009).

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