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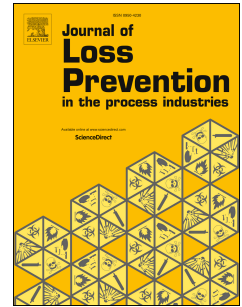
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Oil Transportation in Pipelines with the Existence of Ice

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ABSTRACT

In Arctic environment, ambient temperature can drop below the freezing point, which may lead to ice formation in the oil transportation pipelines. Natural hazards can also cause freezing in the liquid transportation system. The formation of ice can cause flow assurance and process safety issues, such as restricting flow path, pipeline plugging, failure of pipeline components, release of hazardous liquid, and fire. Restricting of flow path causes additional burden to upstream pumping system, while pipeline plugging leads to shutdown of the pipeline system and causes tremendous cost to remediate plugging. The incidents with hazardous liquid release and fire can also lead to enormous expenses. This paper investigates the risks of ice formation in the pipeline and its effect on the transportation system. The experimental tests were performed in a 2-inch diameter carbon steel flow loop. Pressure, temperature, and differential temperature were measured during the test. The experimental results show that an annular ice deposition layer was observed at the pipe inner wall, which restricted flow path and caused an increased differential pressure. The deposition of ice on pipe surface required a negative temperature gradient. Ice accumulations were identified at the low spot in front of the flow meter, the inserted thermocouples, and the perforated plate. The deposition and accumulation mechanisms are discussed. Both the ice layer on the pipe surface and ice accumulation at the pipeline components were porous, indicating the formation mechanism was due to small ice crystals sticking to the pipe surface. The study on deposition and plugging mechanism can help provide a guidance to prevent hazardous liquid transportation damages triggered by ice plugging.

Keywords: Ice formation; Ice and wax deposition; Pipeline plugging; Flow assurance; Hazardous liquid transportation; Prevention

Introduction

Oil companies have taken aggressive measures to ensure continuity in oil supply to satisfy global energy needs, which led to the oil and gas exploration and production activities in harsh environments including extremely low temperatures. In 2008, the U.S. Geological Survey (USGS) estimated that the existing fields beyond the Arctic Circle account for 10% of the

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