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Reverse S-Lay Method for Pipeline Decommissioning

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Abstract

This paper explores the criteria and considerations for employing the reverse S-lay method for the large-scale decommissioning of pipelines with diameters ranging from 6 inches to 18 inches in the Gulf of Thailand.

Through methodical recovery analysis and a structured safety approach adhering to DNV-ST-F101 standards, the objective is to establish comprehensive guidelines that ensure safety and enhance recovery rates.

Joint detailed risk assessment workshop was established within Decommissioning Contractor, Asset Owner and DNV as the regulator. The key scenarios were evaluated collectively to identify potential risks, including internal and external pipeline conditions, operational uncertainties, personnel and vessel safety.

Introduction

The demand for efficient massive offshore pipeline removal techniques has led to advancements in pipeline recovery strategies. The study focuses on engineering solutions tailored for 6-inch to 18-inch pipelines reverse S-lay recovery operations, specifically addressing challenges related to the pipeline recovery process, underwater stability, dynamic forces, and compliance with DNV-ST-F101 standards.

Adhering to DNV acceptance criteria for S-lay recovery presents significant challenges due to the uncertain condition and integrity of pipelines that have been in service for up to 40 years. These difficulties are compounded when the pipelines have been out of operation for extended periods, increasing the complexity of ensuring compliance.

Specific acceptance criteria for pipeline decommissioning are demanded to be developed in order to address the unique challenges associated with decommissioning activities, particularly when using the unconventional method i.e. reverse S-lay. These criteria consider the distinct conditions of aging pipelines, which differ significantly from those encountered during installation. The goal is to maximize recovery performance while ensuring strict adherence to industry codes of practice without jeopardizing the on-site operational safety.

Methodology

Methodology and analysis are derived from the stems of the unique conditions and challenges posed by the reverse S-lay method in the context of decommissioning rather than installation. Unlike traditional pipeline installation, decommissioning by reverse S-lay faces distinct operational and structural risks due to the following factors:

1. Reduced Integrity Importance: In decommissioning, the structural integrity of the pipeline itself is less critical than during installation. The main concern shifts to the safety of the vessel, personnel, and the surrounding environment rather than the pipeline's long-term durability.
2. Environmental and Safety Risks: With decommissioning, failure could lead to environmental hazards such as contaminated water leakage and potential damage to the vessel or nearby assets. Contaminants from residual hydrocarbons, as well as compromised pipeline integrity, increase the stakes for surrounding safety.
3. Pipeline Condition Uncertainty: The pipelines in question have been submerged for extended periods and may have deteriorated due to corrosion, marine growth, or concrete coating degradation. This unpredictability affects both handling and structural resilience, necessitating tailored criteria to account for reduced thickness, structural weaknesses, and external coatings.
4. Modified Safety Factors: Due to the reduced importance of pipeline integrity and the uncertainties of pipeline condition, modified (often lower) safety factors are applied. Acceptance criteria must balance the reduced risk of pipeline failure with the need for operational safety measures.
5. The reverse S-lay method presents distinct mechanical challenges, such as specialized tensioning needs and complex roller interactions, which set it apart from traditional installation techniques. To address these unique operational uncertainties, acceptance criteria are tailored with adjusted integrity and safety factors. These adaptations account for potential deformations, including variations in pipe wall thickness, local buckling risks in overbend and sagbend regions, stinger tip clearance considerations and top tension management.

In summary, the development of specific acceptance criteria is driven by the need to address the distinct operational, structural, and environmental risks inherent in pipeline decommissioning by reverse S-lay. These criteria ensure safe and effective retrieval under conditions where pipeline condition is less predictable, and risks to personnel and the environment are prioritized over pipeline integrity.

Results

1. **Reverse S-Lay Configuration**: The reverse S-lay method was selected due to its suitability for pipelines of varying diameters, especially in water depths up to 75 meters. The approach includes stinger configurations with two sections to control the curvature of the pipeline during recovery.

2. **Pipeline Properties**: 6-inch to 18-inch pipelines with various wall thicknesses and grades (e.g., X42 and X52). The minimum wall thicknesses were determined to qualify the pipelines suitable for Reverse S-Lay method.

3. **Barge Tension and Dynamic Analysis**: The HLPV S1200 tensioner loading is higher due to pipeline recover in flooded condition.

4. **Sensitivity Analysis**: Variation in submerged weight due to water absorption, barge tension and stinger elevation to ensure adaptability to environmental changes, such as wave height and water depths.

5. **Local Buckling Combined Loading Criteria:** Load Control Condition (LCC) as the sole criteria for reverse S-Lay failure mode check to evaluates the pipeline in withstand applied loads without experiencing local buckling, which is a critical failure mode that can compromise the pipeline's structural integrity.

Summary and Recommendation

In summary, the Reverse S-Lay method is the optimal option for large-scale pipeline decommissioning projects, enhancing recovery rates while simplifying task planning. Its efficiency has been demonstrated through the successful decommissioning of 16 pipelines ranging from 6 to 18 inches in diameter in the Gulf of Thailand. This milestone marked the first deployment of the Reverse S-Lay method in a pipeline decommissioning project, ensuring safe operations with no environmental contamination from residual hydrocarbons, no asset damage, and, most importantly, no harm to personnel.

Despite numerous risks and challenges identified early in the project, the feasibility of the S-Lay method was ensured by effectively managing and mitigating these risks. This was achieved through a detailed breakdown and assessment of two key factors: reduced integrity importance and environmental and safety risks. These evaluations addressed uncertainties related to pipeline conditions and allowed the adoption of modified safety factor criteria. A comprehensive decision-making approach was essential to balance the need to minimize pipeline failure risks with maintaining operational safety. Prioritizing the safety of personnel and environmental protection over pipeline integrity was paramount. Consequently, the following recommendations were developed and implemented during the engineering phase and the Reverse S-Lay operation:

1. Wall thickness measurements are taken at 8 points around the pipe's circumference on-site before recovery.

2. The Reverse S-Lay method will be applied to pipes with an average wall thickness (varies across the pipe size) which exceeding the minimum requirement specified in the analysis.

3. Sections with wall thickness below the average will be decommissioned using conventional subsea cutting methods.

4. Engineering analysis considering Local Buckling Criteria from DNV-ST-F101 with relaxation on acceptance criteria established by DNV based on a joint detailed risk assessment workshop for decommissioning pipeline.