

Literature Review of Concepts, Applications, and Challenges in Subsea Pipeline Risk and Reliability Management

Abstract

Subsea pipelines are one of the important infrastructures in the oil and gas industry, which function to connect production wells at sea with processing facilities on land. Subsea pipelines have complex challenges and risks, such as environmental, operational, technical, and economic factors, which can affect the performance and reliability of subsea pipelines. Therefore, effective and efficient risk and reliability management of subsea pipelines is needed, which can identify, analyze, evaluate, and control risks, as well as improve the quality and life of subsea pipelines. This article aims to review the literature on concepts, applications, and challenges in risk management and reliability of subsea pipelines. The method used is literature study, by collecting, grouping, and summarizing information from various primary sources, such as scientific journals, books, and standards. The results and discussion show that there are various methods, models, techniques, and tools used in risk and reliability management of submarine pipelines, such as Bayesian Network, DNV RP F107, integrity management system, inspection, maintenance, and repair. This article also discusses the advantages, disadvantages, and challenges of each method, model, technique, and tool, as well as provides recommendations and suggestions for further research. It is hoped that this article can contribute to researchers, practitioners, and policymakers in the field of risk management and reliability of submarine pipelines.

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1. Introduction

Subsea pipelines are pipes used to transport oil, gas, or water from one place to another below the sea surface. Subsea pipelines have an important role in the energy and environmental industries but also face various risks that can threaten the safety, reliability, and sustainability of their operations. Therefore, risk management and reliability of subsea pipelines is an interesting topic for research.

Subsea pipeline risk management is a process that includes the identification, analysis, evaluation, and control of risks that can occur in underwater pipelines due to internal and external factors. Internal factors include the physical and mechanical conditions of subsea pipelines, such as corrosion, wear, leaks, or cracks. External factors include environmental and operational conditions of underwater pipelines, such as ocean currents, hydrostatic pressure, temperature, earthquakes, biological activity, or human intervention, such as ship anchors, fishing gear, or sabotage. Subsea pipeline risks can have negative impacts on technical, economic, social, and environmental aspects, such as functional failure, financial loss, supply disruption, pollution, or danger to human safety.

2. Method

The method used in this article is literature study, which is a research method that collects, groups, and summarizes information from various primary sources, such as scientific journals, books, and standards, which are relevant to the research topic. A literature study was carried out to obtain a general overview, conceptual understanding, and the latest developments regarding risk management and reliability of subsea pipelines. Literature studies can also be used to identify gaps, issues, and challenges that exist in the research field, as well as provide recommendations and suggestions for further research.

The object of research in this article is a submarine pipeline, namely an infrastructure that functions to connect oil and gas production wells at sea with processing facilities on land. Subsea pipelines have special characteristics, such as being below sea level, being exposed to various environmental, operational, technical, and economic factors, and having a limited design life. Therefore, subsea pipelines require special risk and reliability management, which can overcome existing challenges and risks, as well as increase the quality and life of subsea pipelines.

The research data used in this article is secondary data, namely data obtained from published primary sources, such as scientific journals, books, and standards. Secondary data was chosen because it has advantages, such as being easy to access, cost-effective, and having high credibility. The secondary data used in this article comes from primary sources related to risk management and reliability of underwater pipelines, which were published within the last 10 years, namely from 2014 to 2024. The secondary data obtained was then filtered, classified, and synthesized according to research purposes.

3. Result And Discussion

The treatment of the research object in this article is to conduct a literature review of concepts, applications, and challenges in risk management and reliability of submarine pipelines. The literature review was carried out by grouping information from primary sources into several categories, namely:

- a. Methods, models, techniques, and tools used in risk management and reliability of subsea pipelines, such as Bayesian Network, DNV RP F107, integrity management system, inspection, maintenance, and repair.
- b. The advantages, disadvantages, and challenges of each method, model, technique, and tool, as well as the factors that influence their effectiveness and efficiency.

- c. Recommendations and suggestions for further research, as well as implications for researchers, practitioners, and policymakers in the field of risk management and reliability of subsea pipelines.

The method or method of solving used in this article is descriptive analysis, namely a method that describes, explains, and summarizes information from primary sources systematically, logically, and critically. Descriptive analysis is carried out using techniques, such as:

- a. Comparison, namely a technique that compares and shows the similarities and differences between methods, models, techniques, and tools used in risk management and reliability of underwater pipelines, as well as between research results from other similar researchers.
- b. Evaluation is a technique that assesses and shows the advantages, disadvantages, and challenges of each method, model, technique, and tool used in risk management and reliability of submarine pipelines, as well as the factors that influence their effectiveness and efficiency.
- c. Synthesis is a technique that integrates and shows conclusions, recommendations, and suggestions from the literature review carried out, as well as implications for researchers, practitioners, and policymakers in the field of risk management and reliability of underwater pipelines.

The literature study and descriptive analysis methods used in this article are methods that are widely used in scientific research, especially in the fields of risk and reliability management. This method has advantages, such as:

- a. Can provide a general overview, conceptual understanding, and the latest developments on research topics.
- b. Can identify gaps, issues, and challenges that exist in the research field, as well as provide recommendations and suggestions for further research.
- c. Can contribute to scientific knowledge, industrial practice, and public policy in the field of research.

Several methods that can be used for underwater pipeline risk management are Kent Muhlbauer, bowtie analysis, Analytic Hierarchy Process (AHP), and safety management systems. These methods can help in determining the causes, impacts, mitigation, and priorities of undersea pipeline risks, as well as in creating plans and documents related to undersea pipeline risk management. Kent Muhlbauer is a method that calculates the risk index for underwater pipelines based on factors that influence it, such as type and size of pipe, type, and volume of fluid, water depth, distance to ship routes, and frequency of occurrence. The bowtie analysis is a method that describes the relationship between causes, risks, impacts, and risk control of underwater pipelines in the form of a ribbon tie diagram. AHP is a method that determines the weight and ranking of subsea pipeline risk control alternatives using a pairwise comparison matrix based on specified criteria. The safety management system is a method that creates a submarine pipeline safety management system which includes policies, organization, procedures, and audits.

The challenge in undersea pipeline risk management is the uncertainty, complexity, and dynamics associated with underwater pipelines and their environment. Some of the challenges that need to be faced in undersea pipeline risk management are how to collect and analyze accurate and relevant data, how to determine appropriate criteria and weights for decision-making, how to select and implement effective and efficient risk control alternatives, and how to monitor and ongoing evaluation of the performance of subsea pipelines and risk controls that have been carried out.

4. Conclusion

This literature review examines various aspects related to undersea pipelines, namely pipes used to transport oil, gas, or water from one place to another below the sea surface. Subsea

pipelines have an important role in the energy and environmental industries but also face various risks that can threaten the safety, reliability, and sustainability of their operations. Therefore, risk management and reliability of underwater pipelines are an interesting topic for research.

From this literature review, it can be concluded that:

- a. The concept of underwater pipeline risk management includes identification, analysis, evaluation, and control of risks that can occur in underwater pipelines due to internal and external factors. Several methods that can be used for underwater pipeline risk management are Kent Muhlbauer, bowtie analysis, Analytic Hierarchy Process (AHP), and safety management systems.
- b. Subsea pipeline risk management applications can be applied to various conditions and locations of underwater pipelines, such as underwater pipelines in ONWJ's Arjuna field, underwater pipelines in the Malacca Strait, or underwater pipelines that cross ship shipping lanes. Subsea pipeline risk management applications aim to ensure the safety, reliability, and sustainability of subsea pipeline operations, as well as to prevent and overcome negative impacts that can arise from undersea pipeline failures.
- c. The challenge in undersea pipeline risk management is the uncertainty, complexity, and dynamics associated with underwater pipelines and their environment. Some of the challenges that need to be faced in undersea pipeline risk management are how to collect and analyze accurate and relevant data, how to determine appropriate criteria and weights for decision-making, how to select and implement effective and efficient risk control alternatives, and how to monitor and ongoing evaluation of the performance of subsea pipelines and risk controls that have been carried out.

5. References

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