Risk-Based Assessment for the Existed Submarine Pipeline

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ABSTRACT

Submarine pipeline can be regarded as a system of complex technique, high safety requirement and severe environment, which makes it full of hazards from the initial design phase to the final operation. Considering the characteristics of the submarine pipeline, the risk assessment method should be a comprehensive approach that combines the theoretical analyses and the engineering experiences. In this paper, based on the failure analysis of the submarine pipeline, together with the risk assessment procedures and risk level classification, the risk of an existed gas transmission pipeline is evaluated.

KEY WORDS: submarine pipeline, risk assessment, failure, ALARP (as low as reasonably practicable)

INTRODUCTION

Since the first submarine pipeline was laid by Brown & Root Company in Mexico of Gulf in 1954, the total length of all kinds of submarine pipelines has been increased to the order of 10^5km during the past several decades. Currently, submarine pipeline has played a very important role in the oil and gas transmission during the development of offshore oil and gas field. As for China, especially from 1980’s to present, 47 oil and gas fields have been developed and 138 submarine pipelines have been laid in Bohai Bay, East China Sea and South China Sea. The total amount of pipelay has exceeded 4000km, which covers wide range of sea area and various kinds of scales.

The submarine pipeline is full of hazards and encounters the high probability of failure from the initial design phase to the final operation, which is closely related to its rough environment. The operating pipeline in the sea is subjected to the loads of the combination of waves, currents, tides and corrosion, as well as the hazards of dropped objects and trawling. Therefore, the submarine pipeline is easily failed during its entire life cycle. According to the MMS (Mineral Management Service) statistical data of failure events happened in Gulf of Mexico in 1967-1987, 690 accidents of submarine pipelines have occurred, averaged up to 35 annually. Consequently, it is necessary to conduct the risk assessment for the submarine pipelines.

FAILURE REASONS OF SUBMARINE PIPELINE

Generally speaking, the failure reasons of submarine pipeline can be categorized as corrosion, the third party activity, defects of material, welding and structure, natural forces, installation, improper handling and other unknown reasons. Furthermore, the main effects of the submarine pipeline induced by the natural forces are represented as seabed evolution, local seabed scour, span, seabed gliding, seabed liquefaction and so on (Jin et al, 2004).

As a matter of fact, the damage of the submarine pipeline caused by the seabed motion is the interaction result of current-pipeline-external forces. For the sandy seabed scoured by the waves and currents, the undercutting phenomena will occur; while the silt and fine sandy seabed subjected to storm tide and earthquake will be liquefied. When the pipelines are laid on these kinds of unstable seabed, strength and deformation failure may possible occur due to the seabed collapse, seabed slide and/or seabed scour (Yu, Chen and Li, 2007).

In most cases, the failure of submarine pipeline is induced by the combinations of the abovementioned different factors, which is closely related to the operational life and environment. For the submarine pipeline serviced for a long period of time, corrosion and accessories aging are the main causes for the failure. However, the pipelines laid on sandy seabed may possibly be destroyed by the wave and current scour and motion of the seabed, and those in the fisheries area, the trawling and the dropped objects are the main concerns.

RISK ASSESSMENT METHOD OF PIPELINE

To ensure the safety of operation, it is necessary to carry out the risk assessment for the submarine pipeline, which is the efficient means to reach the maximum economic benefit and accomplish the transformation of the management techniques, i.e. from safety management to risk management and empirical management to scientific management as well (Sun, Zhang and Zhong, 2005). Risk assessment of the pipeline systems is to identify and evaluate the risk, which includes the evaluation of the pipeline and its accessories during the entire life cycle.

Risk assessment method can be classified as qualitative method, semi-quantitative method and quantitative method (Li et al, 2004; Liu, 2006; Xiao, 2005). Fig.1 shows the procedures of integrity management system, which indicates that the risk assessment is the basis of inspection, monitoring and integrity management. Thus, the risk level must be ranked according to the risk evaluation for the pipeline. It means that a risk ranking criterion should be presented, which is used for classifying the pipeline due to the corresponding risk level.