Risk-Based Inspection and Integrity Management of Pipeline Systems

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ABSTRACT

This paper outlines methodologies and analytical tools for the Risk Based Inspection and Integrity Management (RBIM) of pipeline systems. The objective of a risk based integrity management (asset management) approach is to ensure and maintain the required confidence in the pipelines integrity and hence maximise its operating availability, whilst optimising the resources used to ensure the pipeline integrity e.g. the planning of inspection intervals and methods, repairs etc.

The basic steps of a pipeline system RBIM are:

a) Establish and define the required levels of confidence in the pipeline's integrity.
b) Develop as detailed knowledge as possible of the pipelines past, present and future operating condition and environment.
c) Systematically evaluate and rank the risks of each potential failure mode specific to the particular pipeline, accounting for and highlighting the uncertainties. This is largely performed at a qualitative level.
d) Time-dependent degradation failure modes (e.g. internal corrosion) considered to be a risk to the pipeline are assessed using spreadsheet based semi-probabilistic structural reliability assessment tools. These are quick and simple to use, predicting the period in which the confidence in pipeline's integrity against a particular failure mode falls below specified levels. A risk based inspection (RBI) planning approach is developed mixing the structural reliability approach with a generic database approach of risk analysis in c) above.
e) A total production maintenance (TPM) approach is considered linking it with risk-based maintenance (RBM).
f) Solutions are then considered to reduce / eliminate the risks considered to be unacceptable and the uncertainties in the integrity management, and to maintain confidence in the pipeline integrity.

KEYWORDS: Risk Based Inspection, Integrity Management, Total Production Maintenance and Pipeline Systems.

INTRODUCTION

The design of Pipeline systems is increasingly being optimised through use of advanced design methods, primarily to minimise the CAPEX (particularly on high CAPEX projects such as major trunk lines). This generally results in less redundancy to extreme loads, reduced toleration to corrosion, third-party defects and fatigue damage, with the expectation that these loads will be monitored and controlled during operation, thus the monitoring and control requirements need to be well defined. Also many pipeline systems are ageing beyond their design life, with an increasing risk of failure and hence need to be inspected and repaired or verified as fit for purpose. Further, the operation of pipeline systems is characterised by fewer multiple-tasked employees supported with more expensive inspection tools.

These industry environments require tools for the application of risk and reliability methods to identify and prioritise among project tasks where the risks are highest from both safety and business view points. For successful operation and maintenance of pipeline systems, it is important to select technologies and methods such that risks are managed in the most cost-effective manner. A good understanding and management of risks is of vital importance in ensuring the integrity of the pipeline.

The development of risk and reliability tools requires the integration of risk analysis, materials technology and structural analysis. Risk analysis is increasingly used for decision making in detailed design, as most risks can be identified and controlled in the design process or requirements for future controls identified. For planning of risk based inspection of pipelines in operation, it is necessary to combine our knowledge of risk analysis, prediction of corrosion and third-party defects and remaining structural strength.

Some of the risk based inspection methods in literatures tend to be too complicated, and can not be practically applied due to a lack of