PIPELINE INTEGRITY MANAGEMENT STRATEGY FOR AGING OFFSHORE PIPELINES

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Abstract

In the North Sea many assets have been in operation for up to 20 years and with original design lives of 25-30years they are nearing the end of their lives. With the shortage of fuel and the improved techniques of extracting these valuable energy supplies the ability to ensure the integrity of aging assets and extending their safe remaining life has become critical.

Having as much knowledge as possible about assets and their pipelines and knowing how to analyse this information has become very important. In offshore pipelines intelligent pigging provides the clearest picture of the integrity of the pipeline. The information from these inspections can then be fed into the many assessment tools available in the market, for example:

Semi-Quantitative Risk Assessments – Identifies the threats and their initiators affecting the integrity of the pipeline

Corrosion Risk Assessments – Analyses the specific risk of internal and external corrosion to the pipeline

FFP (Fitness for Purpose) – Conducts an assessment of the pipeline and its corrosion features according to various standards (B31.G, DNV etc,) to determine immediate repairs.

Corrosion Growth Assessment – using the inputs from the above assessment tools this determines an accurate corrosion growth rate for calculating any future repairs and a re-inspection interval

In general these tools tend to be used individually but put together they could provide a complete picture of the current integrity of the pipeline by assessing all areas of risk. This paper assesses the advantage of combining all of the above, in particular the inclusion of semi-quantitative risk assessments, to provide a more comprehensive assessment of the pipeline. The ultimate aim is to produce an effective integrity management plan to ensure the safe and long operating future of the pipeline.

Introduction

For ageing pipelines, i.e. those pipelines reaching the end of or exceeding their original design life, there is an increasing requirement around the world to defer their replacement and extend their remnant life.

In order to evaluate the actual pipeline condition in service, Operators will implement routine condition monitoring activities; for example on-line process control and monitoring systems, product monitoring, corrosion probes, etc. for internal corrosion and external surveys such as CP and coating condition surveys to monitor external corrosion. The primary aim being to identify at a very early stage any occurrence of accelerated deterioration, i.e. deterioration faster than that accounted for in the original design plan.

It is widely accepted that in-line inspection using intelligent inspection vehicles is a key component of any pipeline integrity management programme which based on accurate and reliable data provides a sound technical basis for planning future maintenance and repair activities.

General approach to Pipeline Integrity Management

An overview of a typical Operators Pipeline Integrity Management System (PIMS) Framework and the practical components for its application are summarised in Figure 1 and Figure 2.

Such approaches are an integral part of pipeline design codes and more recent integrity related guidance documents such as API 1160 [1], ASME 31.8S [2], and general industry best practice in the field of PIMS.

As illustrated in Figure 2, a key step in the integrity management cycle is risk management and planning of inspection, maintenance and repair activities[3,4].

Risk Assessment for Pipeline Integrity Prioritisation and Planning

Risk Based Assessment (RBA) is a systematic approach which aims to reduce the overall risk exposure by focusing on the areas of higher risk. This approach reduces the total scope of work and inspection costs in a structured and justifiable way.

The underlying philosophy of risk based assessment is ensuring pipeline system integrity while maintaining risk at as low a level as is reasonably practicable (ALARP principle).

Risk is generally described as the product of the likelihood of a given failure multiplied by the consequence of that event:

Risk = Likelihood or Probability of Failure X Consequence of Failure

Risk assessment strategies can be applied to pipelines at all stages of their life, from design through to decommissioning. The application of RBA methodologies enables the Operator to:

Identify the primary threats to pipeline integrity,

Rank pipelines in terms of risk (probability of failure and consequences),

Optimise Inspection, Maintenance, Repair (IMR) activities, i.e. defining the appropriate maintenance need and maintenance activities, and

Define an appropriate frequency for conducting the maintenance activity

Combined with a detailed understanding of pipeline degradation mechanisms the primary steps in conducting a risk assessment include (Figure 3)3:

Data collection and storage in a central database

Segmentation of pipeline into sections (e.g. High Consequence Areas).

Consideration of threats, consequences and mitigation to pipeline sections

Relative risk assessments

“What if” capability for sensitivity analysis

Generate report for the reference IMR plan.

This information can be used to optimize and plan inspection and maintenance activities and identify the need for further detailed quantitative risk assessment or fitness-for-purpose assessment. For example such a programme aimed to limit the risk of external corrosion may involve a combination of external coating and CP surveys, internal inspection using intelligent pigs to detect and monitor corrosion.

Fitness-For-Purpose Assessment and Pipeline Integrity (IMR) Plans

At the heart of any pipeline integrity management system is having an understanding of the likely condition of a pipeline and confidence in the data generated from any inspection programme conducted to validate this understanding.

Based on the data generated by the inspection programmes, an Operator can go forward and make decisions related to the current and future integrity of a pipeline, remaining life assessment and appropriate preventative maintenance and inspection activities to maintain the design plan for the pipeline.

Over many years the use of more advanced defect assessment or FFP methods; for example, codes such as RSTRENG, DNV, etc. have gained more widespread application resulting in optimized inspection, maintenance and repair (IMR) strategies. Such methods are fully codified and are an integral part of pipeline integrity guidance documents such as API 1160, ASME 31.8S, and general industry best practice (Figure 4). In combination with risk based assessment methods (RBA), operators can implement optimized and more cost effective IMR approaches while improving pipeline safety and reliability.

It is well known that defect assessment criteria such as ANSI/ASME B31-G can be very conservative and as such may result in unnecessary pipeline repairs. By utilising such alternative integrity assessment approaches (RSTRENG, DNV, etc.) Operators significantly benefit from reducing the number of repairs required during future operation.

However the diagnosis of the causes of corrosion and the determination of realistic corrosion growth rates is the critical input in the determination of the remaining safe working life, timescales for future repairs and re-inspection intervals.

By aligning various data sources, pipeline risk assessment, segmentation of pipeline based on physical parameters (WT, location, pressure, etc.) combined with available internal and external inspection data, areas of high integrity risk or “hot-spots” can be identified and the root cause of the corrosion diagnosed.

Corrosion growth rates can be estimated or predicted using a number of methods depending on the available pipeline data.

Where no previous in-line inspection data is available, predictive models such as, NORSOK, combined with engineering judgement can be applied. Where previous in-line inspection data is available, comparison between repeat inspection runs can be conducted to determine actual corrosion growth rates and compare with such predictive models (Figure 5).

Integrity Management based on Prevention & Mitigation

Only when the active threats/degradation mechanisms have been identified and the corrosion growth rates have been estimated, can appropriate preventative measures be determined which will form the basis of an appropriate, cost effective corrosion management plan.

Combined with a review of corrosion management activities, e.g. review of external corrosion protection CP and coating systems, internal corrosion control/monitoring, correlation with the inspection findings, the primary aim of any integrity management strategy is to diagnose the likely causes of corrosion. On this basis, appropriate preventative measures to minimise further deterioration of the pipeline can be defined. Based on determined corrosion growth rates, predictions of future repairs together with mitigation and re-inspection requirements can be determined.

This approach has been applied routinely for many pipeline Operators to develop pipeline specific integrity plans which (Figure 6) 3[, 5]:

Use advanced defect assessment criteria to avoid or minimise the need for unnecessary repairs

Conduct detailed corrosion growth between repeat ILI runs to assess the effectiveness of corrosion management activities conducted between the successive ILI inspections.

Focus rehabilitation effort and expenditure on hot-spot or higher risk areas

Set optimum re-inspection intervals

Summary

The preceding sections summarize some experience of the practical application of widely accepted and available integrity assessment tools such as risk assessment, Fitness-For-Purpose assessment, etc. to ensure the continued safe operation of such ageing assets. The importance of the early diagnosis of corrosion problems and representative corrosion growth rates for predicting the future Inspection, Maintenance and Rehabilitation (IMR) requirements are highlighted.

References

API Recommended Practice 1160 "Managing System Integrity for Hazardous Liquid Pipelines", First Edition (August 2001)

ASME/ANSI B31.8S "Supplement to B31.8 on Managing System Integrity of Gas Pipelines" (ASME/ANSI B31.8S-2002)

C Argent, I Diggory, J Healy, The use of risk assessment for optimising maintenance expenditure on buried pipelines, BHR Pipeline Protection Conference, November 2005

G Weigold, C Argent, J Healy, I Diggory, A semi-quantitative pipeline risk assessment tool for piggable and unpiggable pipelines. Proceeding of IPC 2006, 6th International Pipeline Conference, September 25-29, 2006.

J Healy, Unpiggable pipelines – the issues and the options. Pigging Products & Services Association (PPSA) Seminar, London, November 2005

Figures & Tables

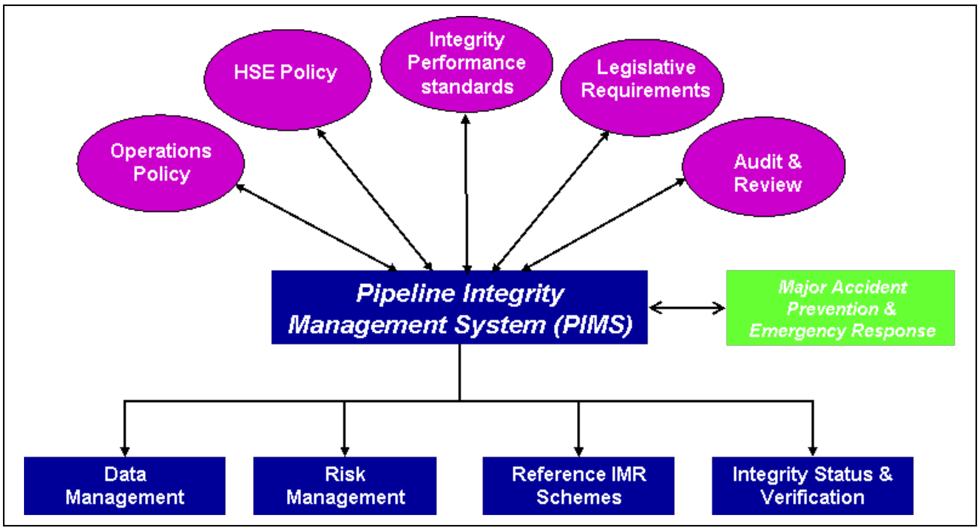


Figure 1: A typical Pipeline Operators Integrity Management Structure

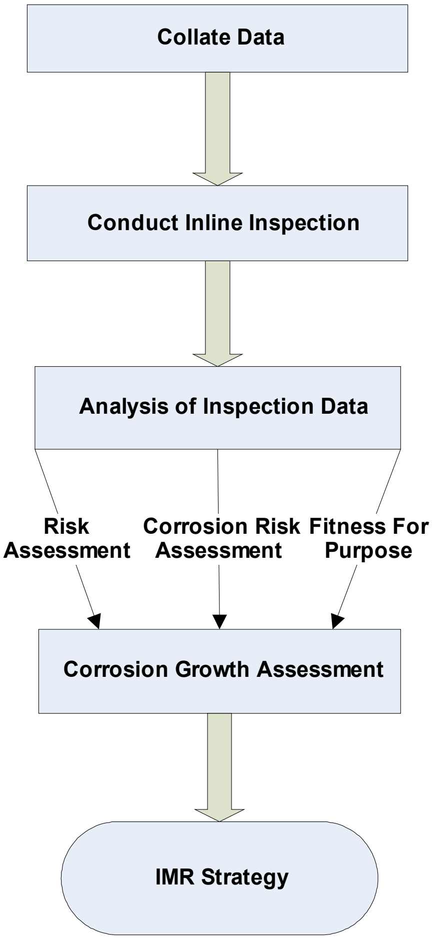


Figure 2: Typical Integrity Management Process

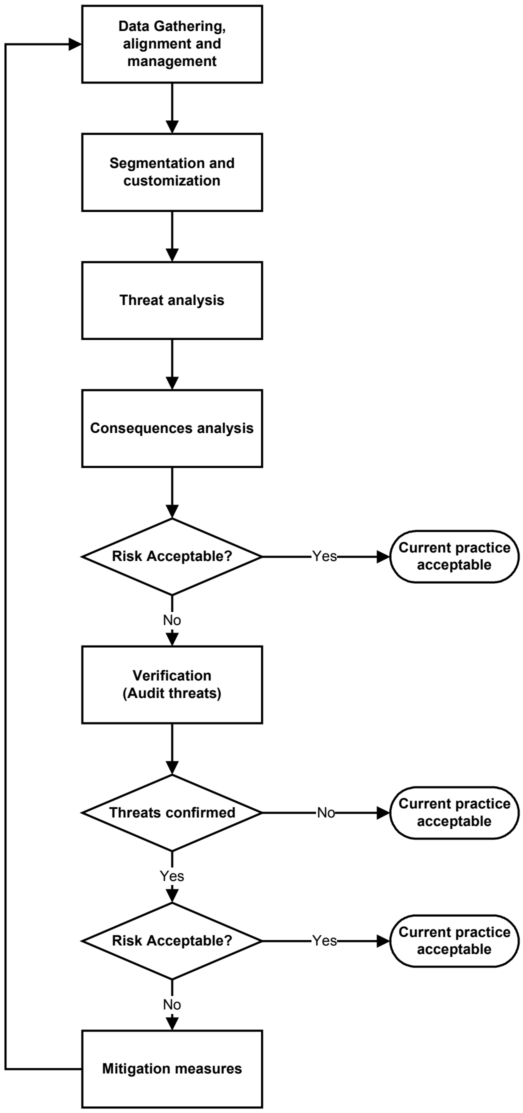


Figure 3: Risk Assessment Process

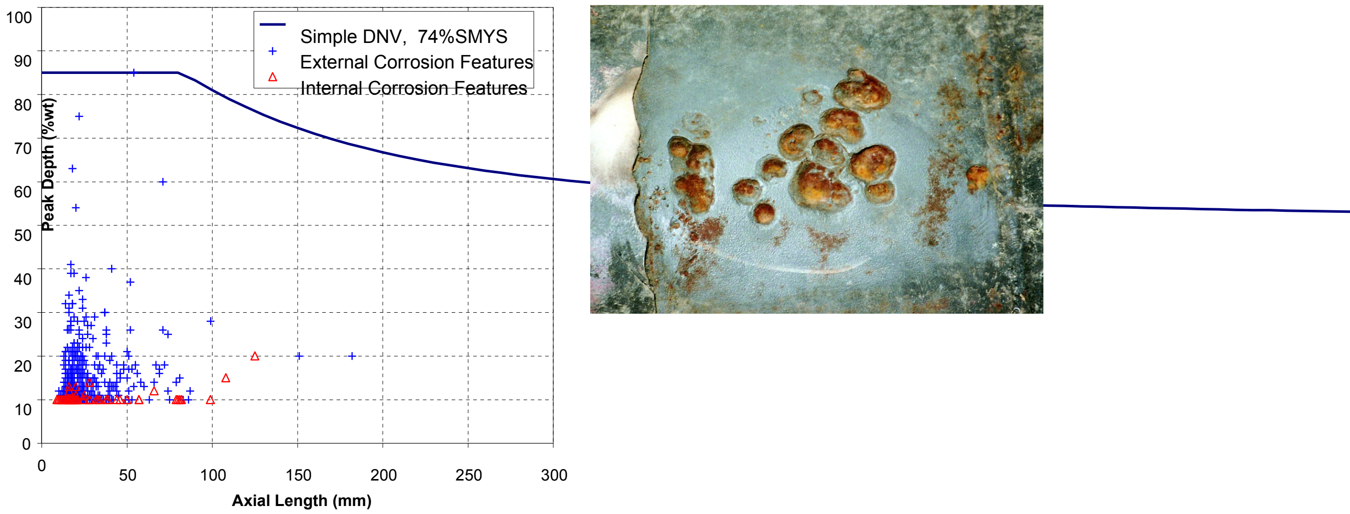
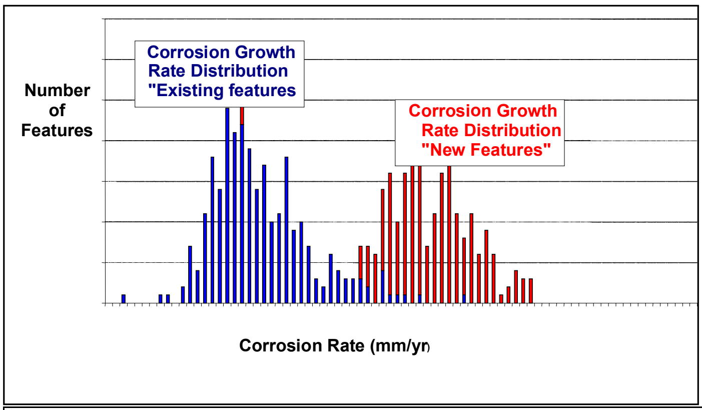
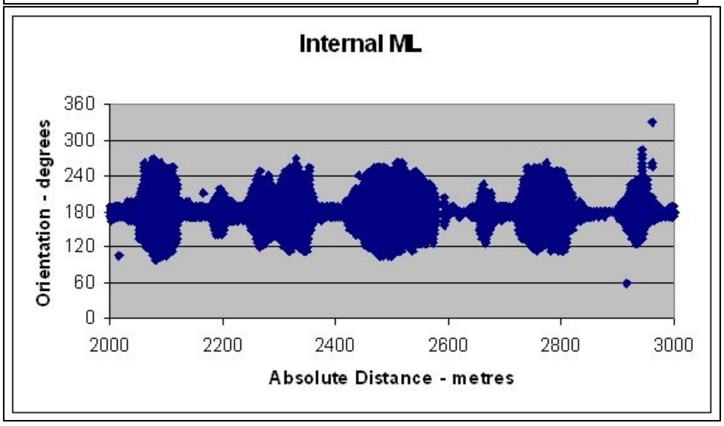


Figure 4: Fitness-For-Purpose assessment and rehabilitation planning





<u>Figure 5: Diagnosis of corrosion causes and determination of corrosion growth rates based on inline inspection data.</u>

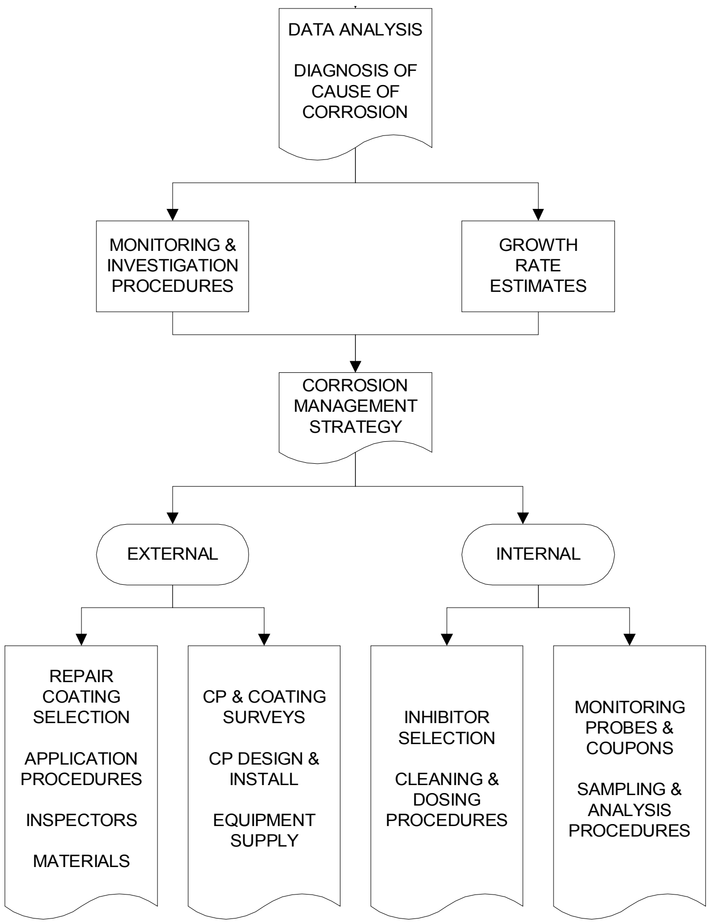


Figure 6: Integrated Integrity Management

External Threats
Impacts
External Corrosion
Structural
Material
Natural Hazards
Fire/Explosion
Construction
Maintenance
Mechanical Failure

Operations & Safety System Threats
Control Failure
Communications Failure
Off Specification Product
Operator Mindfulness
Over Pressure
Under Pressure
Maintenance of Systems
Mechanical Failure (moving systems)

Internal Threats
CO_2 Corrosion
Sulphide Stress Corrosion Cracking (SSCC)
Hydrogen Induced Cracking (HIC)
Microbial Induced Corrosion (MIC)
Galvanic Corrosion
O_2 Corrosion
Erosion
Preferential Weld Corrosion
Flange Face Corrosion
Material Degradation

Table 1: Potential threats to pipeline integrity

[1] API Recommended Practice 1160 “Managing System Integrity for Hazardous Liquid Pipelines”, First Edition (August 2001)

[2] ASME/ANSI B31.8S “Supplement to B31.8 on Managing System Integrity of Gas Pipelines” (ASME/ANSI B31.8S-2002)

[3] C Argent, I Diggory, J Healy, The use of risk assessment for optimising maintenance expenditure on buried pipelines, BHR Pipeline Protection Conference, November 2005

[4] G Weigold, C Argent, J Healy, I Diggory, A semi-quantitative pipeline risk assessment tool for piggable and unpiggable pipelines. Proceeding of IPC 2006, 6th International Pipeline Conference, September 25-29, 2006.

[5] J Healy, Unpiggable pipelines – the issues and the options. Pigging Products & Services Association (PPSA) Seminar, London, November 2005