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Development of KPI's for Ageing Export Pipelines in the UK North Sea

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Abstract: ***Export pipelines are of inestimable value to the oil and gas industry, as they have continuously provided a path and means for hydrocarbon transportation. The most recent report from the UK HSE shows that there are about 1372 pipelines installed in the UK North-sea and about 442 of them are ageing export pipelines. The most unique function of these pipelines is to convey fluids from HC wells to the available processing facility; which are applicable for both onshore and offshore applications. During the useful life of these pipelines, they encounter various degradations that range from fatigue, corrosion, thermal expansion, spans, erosion and many other associated third-party challenges. It is the responsibility of duty holders to ensure that these degradations do not propagate into triggering hazardous and catastrophic incidents, to this effect, it is necessary for operators to protect the state of these pipelines by the application of an efficient management structure known as Pipeline Integrity Management System (PIMS).***

Keywords: Pipeline, Export, Ageing, Key Performance Indicators, PARLOC, OGP, Management, Integrity, Degradation Mechanism, Mitigation, PIMS.

I. INTRODUCTIONS

The movement of hydrocarbon gas and liquids has been made possible over the years via the use of Pipelines which has remained the most dependable fluid conveyance choice due to their safety track record, overall efficiency, operational performance, and most importantly their proven reliability when placed side by side with other numerous means of transportation. Pipeline do not exist without its ow challenges, as they are mostly made up of carbon steel which is corrosion prone. Pipeline integrity management strategies (PIM) must be put in place to maintain a continuously safe working environment for duty holders. PIM is a system put in place by pipeline operators to monitor and ensure that pipelines continue to function safely, so as not to jeopardize safety, prevent pollution and to uphold the protection of valuable pipeline assets. The target of every pipeline operator is to ensure that the threats posed by pipelines remain as low as reasonably practicable. [10]

According to standards such as DNV, API, and ISO, Pipeline Integrity Management has been described as a planned integrated management system which takes into account all operational and HSE issues relevant for the safe operation of pipelines, [10] also defined pipelines as the "heart" of the oil and gas industry of today. The International Standard Organisation, 2008 describes the pipeline system as an assembly of components used in the transportation of HC.

Ageing has been a major subject of discussion for some time now, as pipelines installed some decades ago, are now approaching their end of life. Using the UK North-sea as a case study, reports from oil and gas UK show that about 1372 pipelines are installed in the North-sea (Oil and Gas Authority), of which majority of them were installed in the 1970's. However, little or no efforts have been made to put pipeline Key Performance Indicators in place to serve as performance measurement tools against set targets. Therefore, this paper explores the ideas and resources that can be used in developing key performance indicators that are relevant to ageing pipelines. [5[.

II. OVERVIEW OF UK EXPORT PIPELINES

In line with the progression of the oil and gas industry in the area of field development in increasingly deep water, export pipelines have proven to be critical assets with a high need for maintenance prioritization and effort, it is therefore necessary to manage their integrity and sustainability towards ensuring equipment reliability, availability, safety and to ensure that cost is optimized. The operating and capital expenditures of maintaining export pipelines have been on the increase due to the multiple failures recorded, however, they have remained the safest and most cost-effective means of transportation irrespective of their increasing degradation mechanisms. [2]

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The majority of the ageing oil and gas pipelines are made up of carbon steel, these pipelines were lowered to the sea bed based on already established standards and practices. DNV-RP-F116 recommends that an export pipeline which is of a high integrity must be able to overcome all impacted loads and remain functional throughout its operational life for as long as they are well inspected and maintained [1].



Fig. 1 Showing subsea export pipelines [6]

The majority of the export pipelines which were installed over 20 to 25 years ago are heading towards their end-of-life stage, this is due to various degradation mechanisms acting on them, such as corrosion, fatigue, on-bottom stability and spans which affect the integrity of ageing pipelines. There are various methods and techniques put in place to ascertain the remnant life of these export pipelines, some of which are preventive maintenance, scheduled inspection condition-based monitoring and predictive maintenance [3]. According to reports from the oil and gas authority, about 60% of the ageing export pipelines in the UK North-sea are being used to convey natural gas, this means that continuous distribution of gas greatly depends on export pipeline, so most cities risk losing supply due to the failure of an ageing pipeline. The analysis done by the oil and gas authority also confirms that 13.30% of the pipelines convey gas, 6.6% convey gas-condensate, another 6.6% convey crude oil and the remaining 13% are used to convey associated gas. [12]

III. KEY PERFORMANCE INDICATORS

KPI's are generally known in the Oil and Gas industry as a type of performance measurement tool which are used to gauge an organisation's achievement towards a series of set goals. KPI's are precise and quantifiable measurements that can show the performance of any particular asset, KPI's must be well understood and properly communicated across the board within all stakeholders before they are implemented [17]

KPI's are broadly used as performance measurement against targets, these targets may be procedural, regulatory or operational performance related. KPI's can also be referred to as assessable measurements which shows the critical achievement factor of a scheme or a project. The most significant prerequisite for a KPI is that they must be S.M.A.R.T, as explained in Fig.2 of this paper, there must also be records of the measurement methodology. The most common pipeline related key performance indicators are, no of incidents, severity of incidents and volume of hydrocarbon spilled. [17]



Fig 2. Showing the prerequisite for KPI's using the smart technique [18]

The main aim of this research is to develop key performance indicators that are relevant to ageing pipelines which may begin to show some changes due to weakness caused by loss of pipe thickness, the changes in the pipelines due to ageing can be monitored using condition-based monitoring technology and smart pigs to inspect their internal thickness. An additional layer of improvement can be added by the use of key performance indicators to track performance and create the foundation for a case of life extension [18]

Fig.3 below shows the steps involved in developing KPI's, the 5 different stages are known as, define, analyse, solve, implement and review [18].



Fig. 3: Showing the KPI lifecycle [18]

According to research carried out by HSE on operational issues affecting disaster management, the result shows that the management of integrity of ageing pipelines are based on standards such as API 1160 which covers a vast range of all the recommended practices needed as far as PIMS is concerned.

IV. LEADING AND LAGGING KEY PERFORMANCE INDICATORS

Performance measurements against pipeline operator targets are classified using two distinctive KPI's categories known as lagging and leading KPI's. [4]

Leading performance indicators are used to measure factors that changes right before a company starts to follow a specific pattern. The KPI's developed under this category are expected to provide performance metrics for hands-on pipeline management. On the other hand, lagging indicators for pipelines can be described as indicators that are based on recorded outcomes and result of incidents during a period or phase. According to the HSE, the following are typical examples of leading and lagging indicators for pipelines [13].

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#	Lagging Key Performance Indicators
1	Average volume of Gas release per failure incident (m3)
2	Number of Failure Incidents
	Number of Failure Incidents per 1000 km-years
	Percent of Failures caused by Metal Loss
	Percent of Failures caused by Cracking
	Percent of Failures caused by External Interference
	Percent of Failures caused by Material, Manufacturing or Construction.
	Percent of Failures caused by Other
3	Loss of Containment Incidents
	Rupture percent of failure incidents
	Leak percent of failure Incidents
4	Liquid Releases
	Average volume of liquid release per failure incident (m3)
	Number of liquid releases > 1.5 m3
5	In-line Inspection (ILI)
	Avg. Total ILI length (km)
	Avg. Total ILI length (% of Length in service)
	Avg. Length inspected with ILI metal loss detection (km)
	Percent of System inspected with ILI metal loss detection
	Avg. Length inspected with ILI crack detection (km)
	Percent of System inspected with ILI crack detection
	Average length inspected with geometry ILI (km)
	Percent of system inspected with geometry ILI
#	Leading Key Performance Indicators
1	Average length of pipe in service during the reporting period
2	Number of planned pipe integrity repair sites per 1000 km-year
3	Number of planned Coating repairs
	Metres of coating repaired/replaced
	Metres re-coated per 1000 km
4	Number and percentage of planned Repairs
5	Number and Percentage of planned Replacements

Table 1: Examples of leading and lagging indicators for Pipelines [4]

Table 1 above shows the example of pipeline performance indicators that can be classified as either leading or lagging indicators according to the HSE. Lagging indicators primarily are of higher relevance to the industry since they help in assessing future improvements in terms of operations and maintenance. Leading indicators are more helpful in developing incident databases [23].

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V. SET OF DEVELOPED KEY PERFORMANCE INDICATOR'S

The first set of developed KPI's on Table 2 below are aimed at improving the quality of monitoring during the operational stage of a pipeline. Some important KPI's such as "number of corrosion probes per square area'' can come in handy in monitoring the internal corrosion of pipelines.

Hazard	Proposed Key Performance Indicator	Means of obtaining data for KPI
Corrosion	corrosion inhibitor concentration	Inhibitor Test
	corrosion inhibitor residual concentration	Inhibitor Test
	Maximum corrosion rate (Internal & external)	Monitoring
	Internal corrosion rate	Through inspection
	Corrosion allowance (wall thickness)	During the Design stage
Fatigue	Design fatigue life of welded joint	During Design stage
	Measurement on fatigue crack produced	Through inspection
	Detection of fatigue crack	Through inspection
	measurement of resistance to fatigue by vibration control	Monitoring
Spans	Avoidance of elevated uplands and sea bed unconformities	Commissioning
Fire	Detection level of HC leaks	Monitoring
	Detection of Fire/ smoke and	Monitoring
	Active gas detectors	Monitoring
Erosion	Cumulative thickness loss	Through inspection
	Erosion coupon	Through inspection
Thermal expansion	Equipment capacity pressure Level	Design stage
	Number of pressure cycles monitored over a given period	Monitoring
	The Energy retention capacity of the pipeline	Design stage

Table 2 Showing a list of KPI's for PIM developed using the hazard identification approach.

The KPI's developed in table 2 above are based on major pipeline hazards and degradation mechanisms that have continuously remained a threat to the industry as a whole, with corrosion being the most critical one, followed by fatigue, spans and the others. These set of KPI are suitable for application in cases of risk assessment and RCM optimization. The next set of developed KPI are done based on the different phases of a product lifecycle. In total, there are 28 KPI's that either belong to the design, inspection or the operational stage, which provides another angle of KPI implementation.

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Stage of Implementation	Key Performance Indicator
Design Stage	Hydro testing for the Trunk lines Frequency of pipeline inspection Materials of construction
Monitoring and Inspection	% Of intelligent Pigging Number of times the pipeline has been pigged % Of Cleaning Pigging % Of Direct assessment Inspection for non-pigable trunklines % Of Direct Assessment for feeder pipelines Number of cracks on pipeline Pipeline Network Valve P.M (Preventive Maintenance) Removal of abandoned Trunk Pipeline Network Risk assessment
	Study installation of leak detection. Isolation Procedure for Pipeline Manifold repair status
Operational Stage	Percentage difference between targeted mitigated internal corrosion rate and corrosion rate from monitoring technique Implementation of CMS (corrosion management system) Number of probes per square area to monitor internal corrosion Emergency Planning Internal corrosion rate, after maintenance activities updating maintenance & operation procedure

Table 3: Showing list of 28 KPI's developed according to their stages of implementation.

VI. CONCLUSION

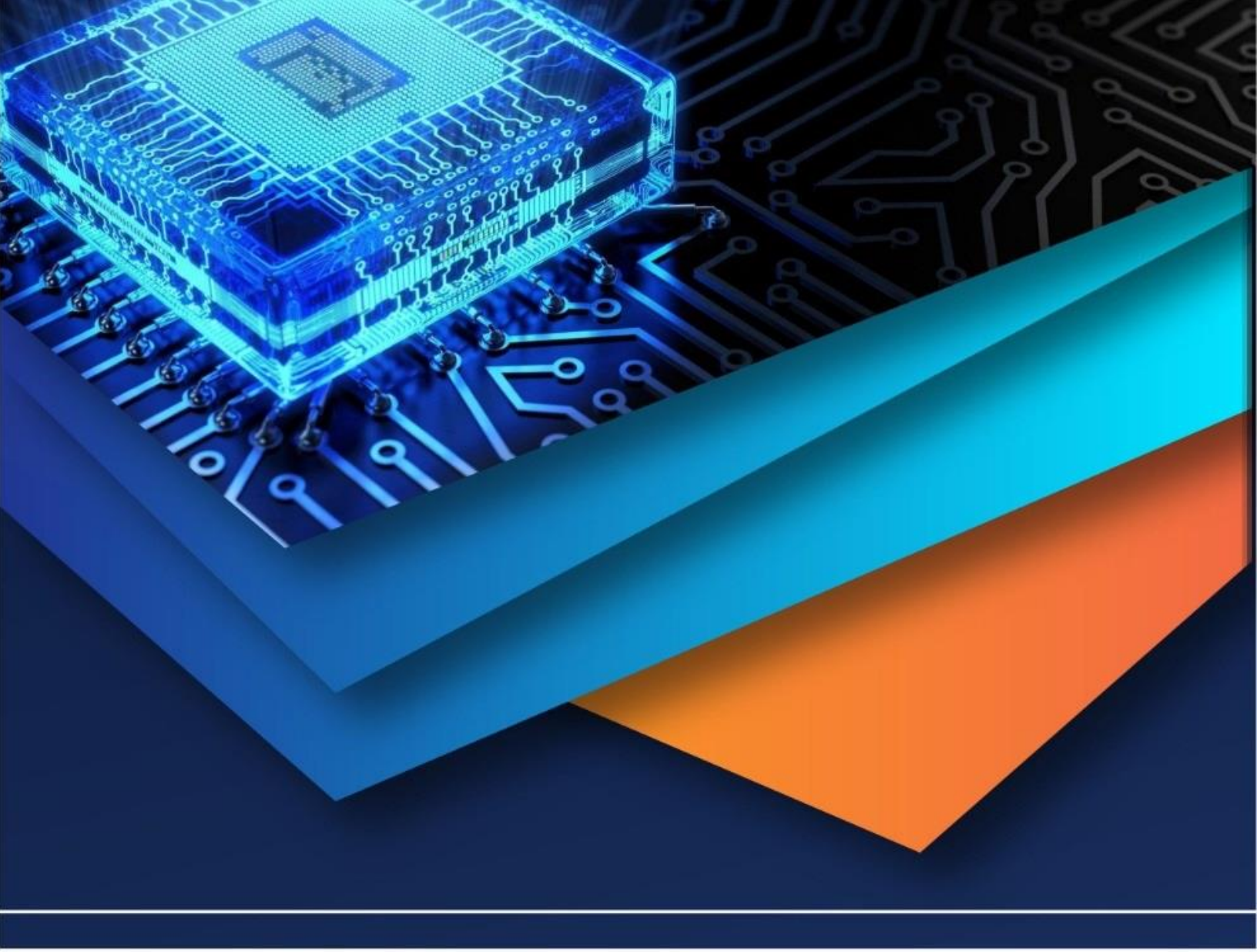
While pipeline ageing remains a major threat which can result in physical weakness leading to incidents such as short or long-term pipeline leakages which can trigger the spread of oil into the offshore environment, resulting in pollution of marine life and risk of fire if not quickly contained.

The KPI's developed for the purpose of this research was carefully put together after consulting the PARLOC and OGP report which provide the most credible pipeline incident-based data in the whole of Europe. The OGP incident database report was used as a second source of input to validate the effects of ageing on export pipelines using the recorded number of incidents as a yardstick. At the end of the analysis done, using the OGP report, the results show that the effects of ageing on the pipelines are unclear, as recorded failure incidents appear to be reducing significantly with time.

This thesis has been able to contribute to existing efforts made in ensuring that the UK offshore region remains safe for Oil and Gas pipeline operations. In order to achieve these set goals, KPI's were identified as a major tool that can be used in improving the entire Pipeline Integrity Management system, and over 40 KPI's have been developed in this paper to add to the already existing body of knowledge.

REFERENCES

[1] Eguiguren, F.G. (2015) 'Pipeline Integrity Management in High Environmental Consequence Areas', pp. 18–20.
[2] Ellinas, P. and Smart, D.T. (1995) 'PARLOC - Pipeline and Riser Loss of Containment: North Sea Experience', IV, pp. 420–427.
[3] Henderson, P.A. (n.d.) 'Ageing Pipelines', 44(0), pp. 0–19.
[4] HSE (2014) 'Appendix 3: Performance assessment criteria', , p. 60.
[5] Hydrawrap (n.d.) Pipeline Inspection & Petroleum Asset Reliability Solution
[6] Ian Nash Sept 2011 (2011) 'Inspection Maintenance and Repair of Deepwater Pipelines', (September)
[7] Pillai, A.P. (2011) '11126 2011', Direct Assessment Pipeline Integrity Management Asokan, (11126), pp. 1–15.
[8] R. molinengo (2014) 'FATIGUE ASSESSMENT OF AN School of Applied Sciences School of Applied Sciences Supervisor: Dr John Sharp'
[9] UKCS (2013) 'Decommissioning of pipelines in the North Sea region 2013'
[10] Veritas, D.N. (2009) 'INTEGRITY MANAGEMENT OF SUBMARINE PIPELINE SYSTEMS OCTOBER 2009', (October)
[11] Report, P. et al. (2015) 'PIPELINE AND RISER LOSS OF CONTAINMENT 2001 – 2012 (PARLOC 2012) The Energy Institute is a professional membership body incorporated by Royal Charter 2003', 2012(1097899)
[12] Oil and Gas Authority, 2015. Oil and gas: infrastructure. DECC. Available at: https://www.gov.uk/guidance/oil-and-gas-infrastructure#guidelines-for-the-completion-of-pipeline-works-authorisations. (Accessed June 1 2016)
[13] Rezaei, C. et al. (2014) 'Asset Integrity Management System Implementation'
[14] Health, T. and Executive, S. (2003) 'PARLOC 2001: The Update of Loss of Containment Data for Offshore Pipelines PARLOC 2001: The Update of Loss of Containment Data for Offshore Pipelines'
[15] Pipeline international (2015) 'Ageing Pipelines Conference is a hit in Belgium'
[16] Tarata, C. (2016) the kpi institute.pdf smart kip's, Available at www.smartkpis.com (Accessed July 5 2016)
[17] Sharp, J. V, 2015. omae2008-57203 development of key performance indicators for offshore structural integrity., pp.1–8.
[18] Titti, F.M. et al., 2011. integrity management during offshore pipeline lifetime. , pp.1–12.
[19] Bai, Y. & Bai, Q., 2010. Subsea Engineering Handbook
[20] A. Stacey, M. Birkinshaw, J.V Sharp, 2008, Life Extension Issues for Ageing Offshore Installations, OMAE2008-57411, 27TH International Conference On Offshore Mechanics and [21] Artic Engineering, 15th-20th June 2008, Estoril, Portugal
[21] Lee, R. and Eng, P. (2016) 'Development of Pipeline Integrity Performance Indicators for Canadian Energy Pipelines', , pp. 1–11.
[22] Hse, S.E. (2006) 'Developing process safety indicators'
[23] Strategy, M. (2008) 'Asset Corrosion Management Using KPIs', (May), pp. 50–54.



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