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## The most crucial pipeline challenges ...

... have been discussed during the 11th Pipeline Technology Conference in Berlin, Germany - with remarkable results and promising outlooks.



**Dr. Klaus Ritter**  
Editor in Chief

Dear Reader,

The exchange of existing experiences and best practices from all over the world is necessary to create and distribute required state-of-the-art technology to face all kind of challenges within the pipeline industry. Therefore, we established the Pipeline Technology Conference 11 years ago, as a professional platform for international dialogue. This dialogue constantly leads to new findings about the industry's most important current and upcoming challenges, which will be discussed in detail in our ptc-special on page 50.

One of these challenges is the slowdown of pipeline constructions in North America and Europe, due to the resistance of local residents and ecological groups. Examples for this development are the failed Keystone Pipeline in Canada / USA, which was cancelled recently, and the decreasing demand in Europe, due to the energy turnaround and the increased usage of LNG. Instead, maintenance and reconstruction offer new possibilities as reliability, safety and longevity become more important.

Then again, there is a significant pipeline boom in South Asia, Eastern Europe and Africa. Those "new" pipeline countries are constantly looking for the best technologies and practices available in order to build up their pipeline networks. And who else could provide that better than the "old" pipeline countries in Western Europe and North America with their unique know-how and experiences?

The 11th Pipeline Technology Conference has been a hub for both hemispheres, offering state-of-the-art technology for pipeline construction, operation and maintenance / reconstruction works likewise. I am convinced, that the international pipeline community will continue to merge in this way and that the ptc will become more important every year.

This brings me to another noteworthy thought: because Africa and South Asia are planning an increasing number of pipeline projects, we have decided to take a next step with our portfolio and to develop a new conference directed towards this emerging markets. In 2017, we will hold for the first time the Pipeline-Pipe-Sewer-Technology (PPST) Conference & Exhibition in Cairo, Egypt. This conference will enable pipeline professionals from all over the world to access an interesting and promising market and to get in touch with key players in the region of South Asia and North Africa.

We are working constantly to foster the exchange within the international pipeline community. You are welcome to make use of the extensive opportunities we created. Kindly find additional information on our websites ([www.pipeline-conference.com](http://www.pipeline-conference.com) / [www.pipeline-journal.net](http://www.pipeline-journal.net) / [www.pipeandsewer.com](http://www.pipeandsewer.com)).

Yours,

> *Dr. Klaus Ritter, Chairman of the ptj Editorial Board / ptc Advisory Committee*



## RUNNING IT SAFE

Pipelines are the safest way for transporting oil and gas over large distances - but they are not inerrable. Regular inspection runs and maintenance operations are critical for a safe and profitable service.

What seems to be common sense is not that self-evident at all, as recent incidents within the United States and other countries are proofing.

The consequences of a lapidary understanding of safety may turn out to be enormously.

Penalties are going into billions, new regulations are unavoidable and a serious loss of public approval and reputation are complementing the misery. To avoid such negative impacts on business a professional and reliable **integrity management** is obligatory. It is the light at the end of the tunnel for pipeline operators and their assets.

# TECHNICAL ARTICLES

JULY 2016  
EDITION 10 

**FOCUS:**  
**INTEGRITY MANAGEMENT**

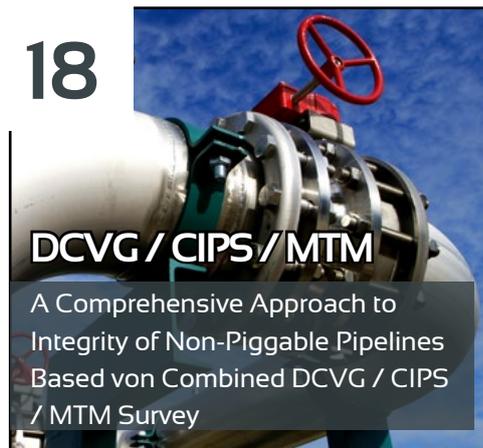
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## Overview

In-Line Inspection of Pipelines -  
An important Element of Integrity  
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## DCVG / CIPS / MTM

A Comprehensive Approach to  
Integrity of Non-Piggable Pipelines  
Based von Combined DCVG / CIPS  
/ MTM Survey

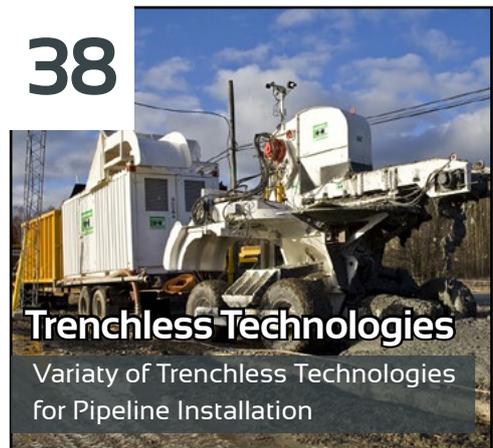
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## Trenchless Technologies

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**WASHINGTON D.C. / U.S.A**

President Obama signed into law the "Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016."

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**WASHINGTON D.C. / U.S.A**

The Pipeline and Hazardous Materials Safety Administration has announced more than \$49 million in Pipeline Safety Base Grants.

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**MEXICO**

Spectra Energy and TransCanada have been awarded a \$3.6 billion contract from the Mexican government to build a 1070-km natural gas pipeline from Corpus Christi to the port city of Tuxpan on the Gulf of Mexico.

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**KENYA / ETHIOPIA**

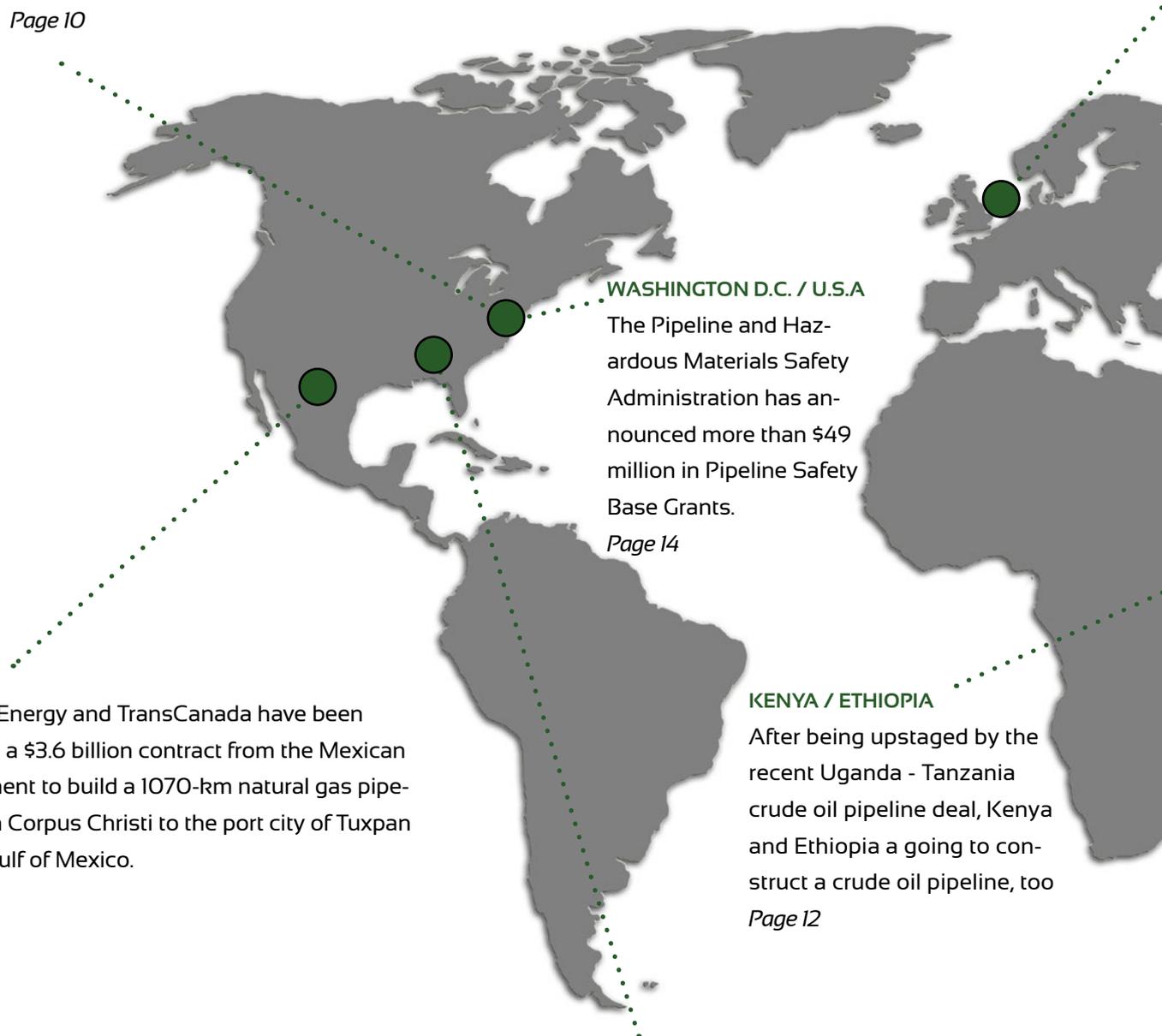
After being upstaged by the recent Uganda - Tanzania crude oil pipeline deal, Kenya and Ethiopia are going to construct a crude oil pipeline, too

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**SOUTHEASTERN U.S.A**

One of the largest natural gas pipeline operators in USA, Kinder Morgan, has made an official announcement that they are selling 50% of its stake in the southeastern pipeline system

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**NORTH SEA**

The protracted low oil price environment is forcing changes in the United Kingdom Continental Shelf (UKCS) infrastructure, as more oil and gas companies divest pipeline assets to rationalize their portfolios.

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**BANGLADESH**

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**OMAN**

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**SAUDI ARABIA**

Saudi Aramco said that it planned to increase the capacity of the 1200 km oil pipeline from Dharan to Yanbu from 5 to 7 million barrels per day by the end of 2018.

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# WORLD NEWS

## PRESIDENT OBAMA SIGNS PIPES ACT OF 2016 INTO LAW

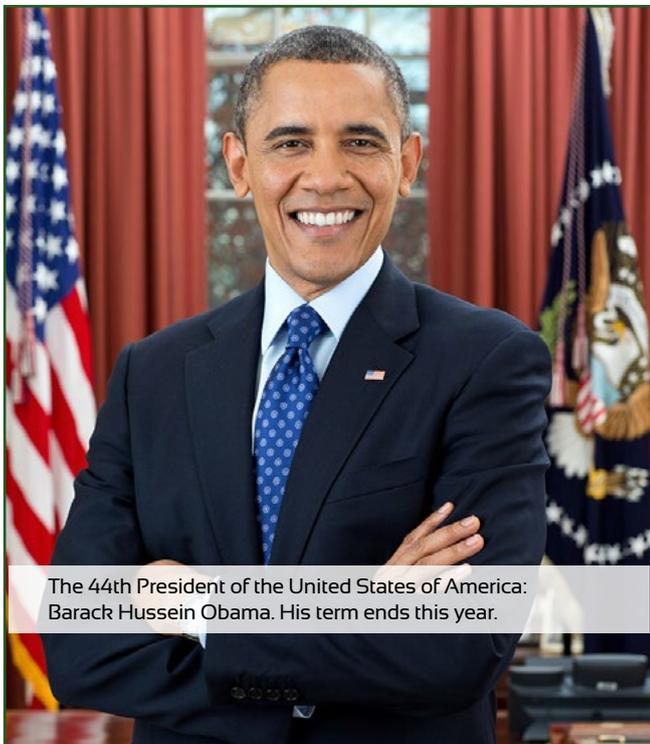
President Obama signed into law the "Protecting our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016." A House amendment to S. 2276 passed earlier this month, and the final legislation sailed through the Senate last week.

The PIPES Act was the product of unusual cooperation between Republican and Democrat members of the Transportation and Infrastructure Committee and the Energy and Commerce Committee, and it will reform the Pipeline and Hazardous Materials Safety Administration (PHMSA) to increase efficiency and transparency.

"We came together, Republicans and Democrats, to improve pipeline safety, and we got the job done with this important law. Every day, American families and businesses depend on safe and efficient energy transportation. The PIPES Act will ensure that our nation's 2.6 million miles of pipelines continue to provide critical access to energy, and we are proud of the bipartisan work that made this effort a success," said Transportation and Infrastructure Chairman Bill Shuster (R-PA), among others.

The PIPES Act will update safety regulations and require pipeline operators to embrace new technologies to reach the goal of zero pipeline incidents.

Don Santa, president and chief executive officer of the Interstate Natural Gas Association of America, added "this legislation, which continues to authorize the Pipelines and Hazardous Materials Safety Administration, focuses PHMSA to complete the regulatory mandates under the Pipeline Safety, Regulatory Certainty and Job Creation Act of 2011 and requires PHMSA to set minimum federal safety standards for underground natural gas storage facilities which will complement our efforts."



The 44th President of the United States of America: Barack Hussein Obama. His term ends this year.

## YOKOGAWA LOOKS TO GROW ITS SCADA BUSINESS AFTER WINNING BIG ORDER FOR GAS PIPELINE IN BANGLADESH

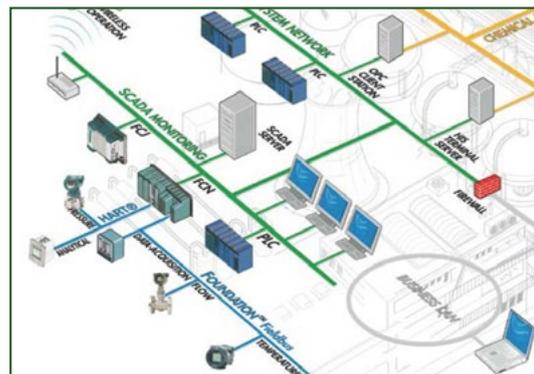
Yokogawa, an innovative US\$3.7 billion company engaged in industrial automation and control (IA), test and measurement, and aviation and other businesses segments worldwide, has announced that it has received a large order from the Gas Transmission Company Limited (GTCL) in Bangladesh for a gas distribution pipeline project in the country. This project will involve the revamping, modernization, and expansion of GTCL's existing supervisory control and data acquisition (SCADA) system.

GTCL owns and operates a network of pipelines for the nationwide transmission of gas from gas fields that are primarily concentrated in the eastern part of the country. GTCL is planning to build an integrated SCADA monitoring and control system that will ensure the stable and efficient supply of gas to three of the country's eight administrative divisions: Dhaka, Chittagong, and Sylhet. GTCL plans to increase its gas transmission volume to 550 million standard cubic feet per day (MMscfd), up from 400 MMscfd in 2013.

This order is for FAST/TOOLS SCADA software and a STARDOM™ network-based control system for pipeline monitoring, DPharp EJA and DPharp EJX series differential pressure/pressure transmitters, other field instruments, a closed-circuit television (CCTV) system, and a telecommunications system for central monitoring and control. Targeting delivery within 22 months, Yokogawa India will be responsible for the engineering, installation, and commissioning of these systems.

Tsutomu Murata, managing director of Yokogawa India, commented "I am honored to receive this order, which is Yokogawa India's largest project to date in Bangladesh. By carrying out this large project, we aim to help ensure a stable energy supply for the people of Bangladesh."

In accordance with its Transformation 2017 mid-term business plan, Yokogawa is strengthening its efforts to drive up sales by providing solutions for pipelines and other oil & gas midstream applications. Encouraged by its success in winning this order, Yokogawa plans to expand its control business in the midstream applications segment.



Yokogawa SCADA System Layout (© 2016 Yokogawa)

## SPECTRA ENERGY AND TRANSCANADA TEAM UP TO BUILD A 1070-KM GAS PIPELINE FROM TEXAS TO MEXICO

Spectra Energy and TransCanada have been awarded a \$3.6 billion contract from the Mexican government to build a 1070-km natural gas pipeline from Corpus Christi to the port city of Tuxpan on the Gulf of Mexico. The pipeline, carrying shale gas from the Eagle Ford rock formation, will ultimately connect with Mexican power plants to help meet the country's growing demand for energy.

Spectra will build the \$1.5 billion portion of the pipeline from Nueces County to the Mexican border at Brownsville. From there TransCanada, in a joint venture with a Mexican subsidiary of San Diego-based Sempra Energy, will continue constructing the \$2.1 billion portion of the newly - named Sur de Texas pipeline from the border into Tuxpan.

"Spectra Energy is pleased to have secured the bid to build and operate this critical infrastructure, which will provide clean-burning and reliable natural gas to support Mexico as its electric generators shift away from fuel oil and imported LNG," said Bill Yardley, Spectra's president of U.S. transmission and storage.

Yardley's comments were reinforced by Russ Girling, TransCanada's president and CEO: "We are extremely pleased to further our growth plans in Mexico with one of the most important natural gas infrastructure projects for that country's future."

## KINDER MORGAN TO SELL ITS SOUTHEASTERN PIPELINE SYSTEM'S 50% STAKE

One of the largest natural gas pipeline operators in USA, Kinder Morgan, has made an official announcement on July 10 that they are selling 50% of its stake in the southeastern pipeline system. Southern Company is buying half of the equity interest in the Southern Natural Gas pipeline system, which will be continued to be operated by Kinder Morgan. This agreement between the electrical and gas utility Southern Company and Kinder Morgan will pursue certain growth opportunities for developing the natural gas infrastructure.

The prolonged course of energy downturn had resulted Kinder Morgan to accumulate debt. By selling half of its southeastern pipeline system, it will immediately pay down debt, says Dave Conover, a spokesperson of Kinder Morgan.

According to the reports, the Southern Company will pay \$1.47 billion to acquire half of the equity interest in the pipeline network that stretches 7,600 miles by connecting natural gas sources along the Gulf Coast to South Carolina, Alabama and Georgia.

"We plan to use all of the proceeds from this transaction to reduce debt at KMI. This is another step towards achieving our stated goals of strengthening our balance sheet and positioning the company for long-term value creation," said Steve Kean, the President and CEO of Kinder Morgan.



Spectra Energy Natural Gas Pipeline Construction, Lower-In

## OMAN TO BUILD MAJOR PETROLEUM PRODUCTS PIPELINE FROM MUSCAT TO SOHAR

With the goal of optimising the overall cost of transport and distribution of oil products in Oman, the state-owned Oman Oil Refineries and Petroleum Industries Company (Orpic) is investing \$320 million for building a 290 km-long pipeline between Muscat and Sohar.

The Muscat Sohar Pipeline Project (MSPP) will connect the Mina Al Fahal and Sohar refineries to an intermediate distribution and storage facility at Jifnain, as well as to a new storage facility at Muscat International Airport, which will receive aviation fuel directly from the pipeline. Construction will begin this year and the pipeline is expected to be operational in 2017.

The MSPP will remove the need for Orpic to ship and truck refined products. Apart from improving efficiency and lowering costs, the pipeline will reduce the number of fuel-tank truck journeys in and around Muscat. Heavy fuel-tank truck traffic in Muscat is expected to drop by 70%, which will contribute to cleaner air in and around the capital.

The Muscat Sohar Product Pipeline is a strategic project of Orpic, aimed at fulfilling its vision of building an Omani integrated refining and petrochemical business.



Muscat Sohar Pipeline Project (© 2016 Orpic)

## KENYA, ETHIOPIA AGREE TO CONSTRUCT CRUDE OIL PIPELINE FROM ADDIS TO LAMU

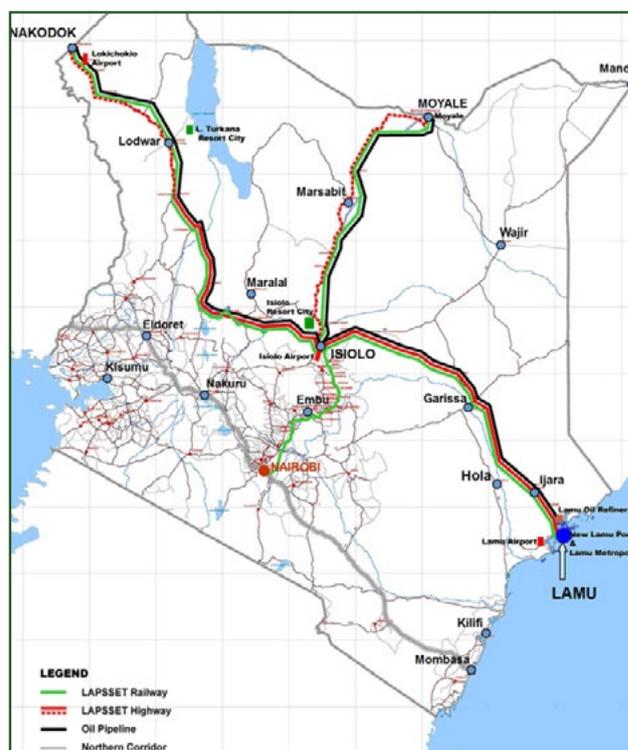
After being upstaged by the recent Uganda - Tanzania crude oil pipeline deal, Kenya and Ethiopia have agreed to construct a crude oil pipeline from the coastal town of Lamu to Addis Ababa.

The oil pipeline is one of several joint infrastructure projects to integrate the region under the Lamu Port-Southern Sudan-Ethiopian Transport (Lappset) corridor. Ethiopia is also considering the export of natural gas following recent vast discoveries in the Ogaden Basin.

President Uhuru Kenyatta made the pact with Ethiopian Prime Minister Hailemariam Desalegn in Nairobi.

Kenya is set to start construction of the Euro 1.9 billion (Sh 210 billion) crude oil pipeline to be completed in 2021, according to Ministry of Energy and Petroleum.

Overall, Kenya and Ethiopia entered into five pacts, including cooperation in sports, cross-border livestock, health and education.



Lamu Port-Southern Sudan-Ethiopian Transport (Lappset) corridor (© By Nairobi123 (Own work) [Public domain], via Wikimedia Commons)

## SAUDI ARAMCO PLANS BIG BOOST IN CAPACITY OF 1200-KM EAST/WEST PIPELINE

Saudi Aramco, the world's largest exporter of crude oil, said this week that it planned to increase the capacity of the 1200 km oil pipeline from Dharan to Yanbu from 5 to 7 million barrels per day by the end of 2018. This would represent a 40 percent increase in production.

The company is also expanding refinery and petrochemical plants capacities in Yanbu on the Red Sea. The extra crude shipments would be used to service these various new units.

Saudi Aramco has discovered several new oil and gas fields during the past year. Khalid al-Falih, who was appointed energy, industry and mineral resources minister on May 7 and is also Aramco's chairman, said that despite low oil prices, the company has reached record levels of oil production and gas processing.

"There's no let up in Aramco's plans for downstream expansion, so this would help in making sure they eliminate any bottlenecks in shipping crude," Edward Bell, a commodities analyst at lender Emirates NBD PJSC, told Bloomberg by phone from Dubai. "There's room for considerable demand growth both domestically and for export."

Saudi Aramco is headquartered in Dhahran (© 2016 Saudi Aramco)



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**DELOITTE SURVEY HIGHLIGHTS WELL-PERFORMING PIPELINE INFRASTRUCTURE MARKET IN THE NORTH SEA**

The protracted low oil price environment is forcing changes in the United Kingdom Continental Shelf (UKCS) infrastructure, as more oil and gas companies divest pipeline assets to rationalize their portfolios.

Given the fact that these assets have delivered solid and consistent returns over the past five years, there is a sizable market among private equity and specialist infrastructure funds. Indeed, business advisory firm Deloitte's latest European Infrastructure Investors Survey noted that pipelines have performed well compared with other infrastructure, providing an internal rate of return (IRR) on pipelines of 14% in the period 2013-2016.

Shaun Reynolds, Director of Deloitte Transaction Services, said "the ownership model has evolved, driven by the maturity of the basin and the low oil price. Established players are divesting to shore up their balance sheets, and infrastructure is comparatively less complex to value and sell, with a ready market at the right price."

In 2015, BP sold its stake in the Central Area Transmission System (CATS) to Antin Infrastructure Partners in a £324 million deal. Antin had bought BG Group out of its stake the previous year, giving it near-complete ownership of the asset.

As global oil production is predicted to rise to 97.6 million a day in 2020 (U.S. Energy Information Administration), placing additional pressure on prices, more operators will likely seek to rationalize their oil and gas infrastructure. According to Reynolds, "deals are brewing in the UKCS – and we'll see more on the infrastructure front in the short- to medium-term."

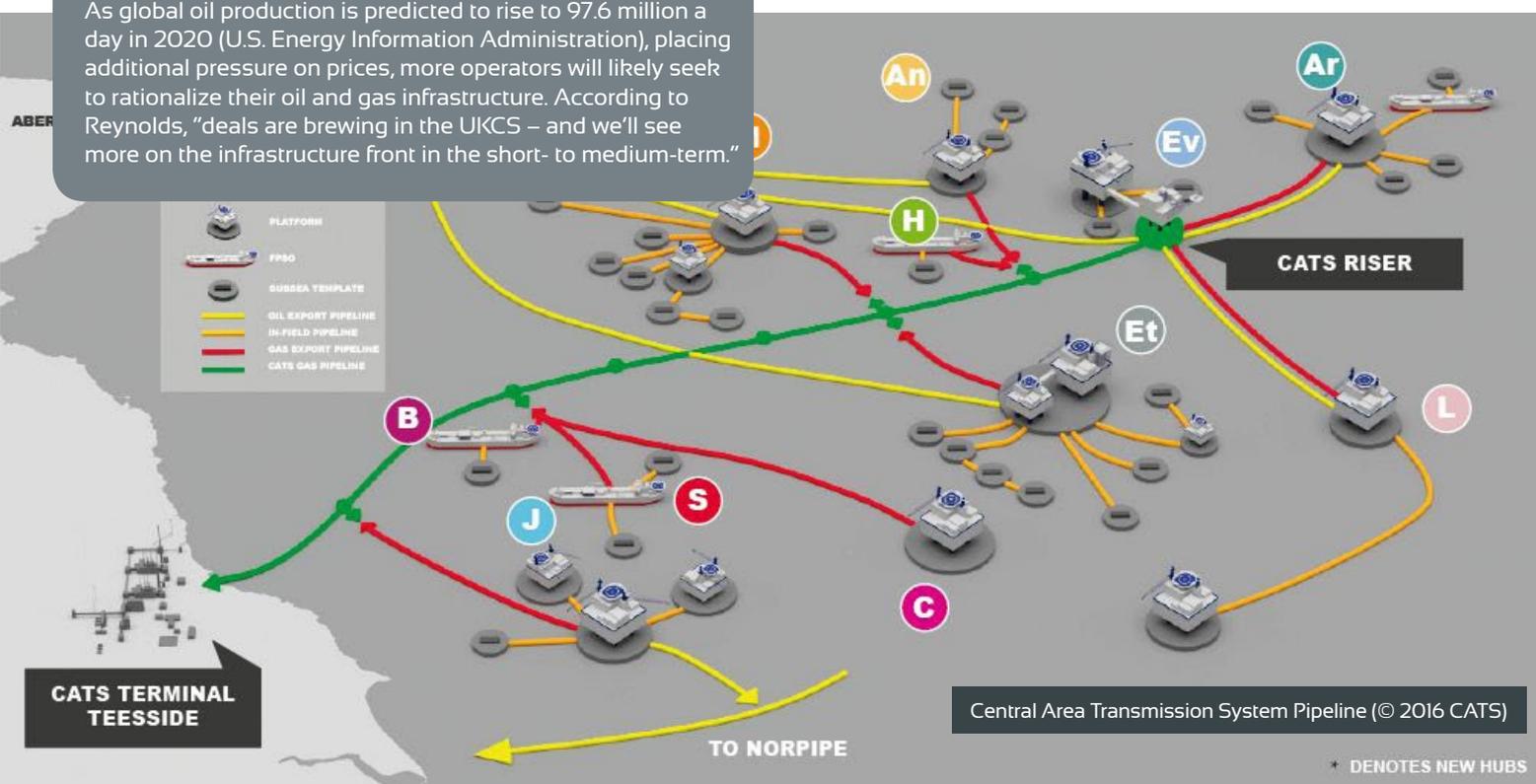
**PHMSA ANNOUNCED \$49+ MILLION IN PIPELINE SAFETY BASE GRANTS**

On July 01, the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation have announced more than \$49 million in Pipeline Safety Base Grants. This reimbursement will be used as a portion of the operating costs for the state pipeline safety programs.

According to Anthony Foxx, the U.S. Transportation Secretary, the partnership between the Federal and the state is the national pipeline safety program's foundation. "State pipeline inspectors oversee more than 80 percent of the nation's 2.6 million-mile pipeline network, and we want to make sure they have the resources needed to ensure the safety of the American people," he added.

Up to 80% operating cost reimbursement is provided by PHMSA's base grants for the state programs that include inspection of intrastate distribution and transmission pipelines for transporting energy products within the boundaries of the state.

PHMSA Administrator Marie Therese Dominguez said, "PHMSA's base grants ensures funding for state programs that employ 340+ inspectors on the front lines of pipeline safety. This is a performance-based grant and is awarded based on the state's estimated program costs and recent performance scores."



Central Area Transmission System Pipeline (© 2016 CATS)

\* DENOTES NEW HUBS

- An**

**ANDREW**  
Cyrus, Faragon and Kinnoull
- Ar**

**ARMADA**  
Gaupe, Maria, SW Seymour, Rev and Varg
- B**

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**ETAP**  
Egret, Heron, Skua, Machar, Madoes, Marnock, Mirren, Monan and Mungo
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**EVEREST**  
North Everest, South Everest, East Everest
- H**

**HUNTINGTON**
- J**

**J-BLOCK**  
Jade, Jasmine, Joanne and Judy
- L**

**LOMOND**  
Erskine
- M**

**MONARB**  
Arbroath, Arkwright, Brechin, Carnoustie, Caley, Shaw, Godwin, Montrose and Wood
- S \***

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## IN-LINE INSPECTION of Pipelines: An Important Element of Pipeline INTEGRITY MANAGEMENT

Dr. Michael Beller  
 Director, Global Strategy Management  
 ROSEN Technology and Research Center GmbH



### INTRODUCTION

Pipelines are a valuable asset and need to be protected. In order to achieve this a modern pipeline integrity management program does usually include regular inspections followed by integrity assessment, and if required repair and rehabilitation measures. A well proven method for the inspection of pipelines, especially high pressure transmission pipelines is the use of automated inspection tools which can survey pipelines from within providing full circumferential and axial coverage. These tools, generally referred to as free swimming in-line inspection tools (ILI) or intelligent pigs utilize non-destructive testing techniques such as: Magnetic Flux Leakage (MFL), Ultrasound Technology (UT), Eddy Current (EC), or a combination thereof to detect, size and locate possible anomalies or flaws.

ILI tools, often also called "traditional ILI" have been used for about 50 years and are proven reliable and accurate. Initially tools were introduced for the detection and sizing of geometric anomalies, such as dents or any type of out-of-roundness of the pipe. Slightly later, in the middle 1960's first tools appeared for the detection and sizing of metal loss. Since then ILI tools have evolved continuously. One area of evolution relates to resolution and measurement accuracies that can be achieved. The other to the range of different types of features that can be detected, sized and identified. Today the ILI tools commercially available on the market cover the inspection of a wide range of flaws and anomalies in the pipeline wall such as metal loss including corrosion, cracks, dents and out-of-roundness or leaks.

Main Categories of Features	Sub-Categories	Examples
Geometric Anomalies	Diameter Changes	<ul style="list-style-type: none"> <li>Dents</li> <li>Out-of-Roundness</li> </ul>
	Pipeline Position	<ul style="list-style-type: none"> <li>Pipeline Movement</li> </ul>
Metal Loss	Wall-Loss without Corrosion	<ul style="list-style-type: none"> <li>Gouging</li> <li>General Corrosion</li> </ul>
	Wall-Loss due to Corrosion	<ul style="list-style-type: none"> <li>Localized Corrosion</li> <li>Pitting</li> </ul>
Material Separation	Laminations Cracks	<ul style="list-style-type: none"> <li>Laminations</li> <li>Fatigue Cracks</li> <li>Hook Cracks</li> <li>Stress Corrosion Cracking</li> </ul>

Table 1: Overview Types of Anomalies and Flaws in Pipelines

### NEED FOR RELIABLE AND ACCURATE DATA

The main purpose of any inspection utilizing non-destructive testing technologies is to collect accurate, reliable and robust data about any flaws and defects which may be present in the pipe wall and in turn impair its mechanical integrity. This data must be turned into useful information in order to be of true value. Understanding the state and integrity of a pipeline, or any pressure bearing asset for that matter, is an important piece of information regarding pipeline integrity management.

The major types of anomalies an inspection aims to identify are the same for all types of pipelines as shown in table 1. As all testing technologies have advantages and disadvantages it is not sufficient to only have access to one particular methodology, see also Beller and Reber (2003) and Beller, Steinvorte and Vages (2015). No single inspection methodology will be able to detect, size and identify all the possible anomalies that may be present in the pipe wall, that being the reason why today a wide range of technologies is being used.

Table 1 shows an overview of the types of flaws that may be present in the steel wall of a pipeline. A very comprehensive overview of the potential types of material flaws can be found in the Macaw Defect Atlas (2015).

Method	Application	Main Mission
MFL	<ul style="list-style-type: none"> <li>Axial Magnetization</li> <li>Circumferential Magnetization</li> <li>Spiral Magnetization</li> </ul>	Metal Loss Inspection
UT	<ul style="list-style-type: none"> <li>Piezo-electric – vertical beam</li> <li>Piezo-electric – angled beam</li> </ul>	Metal Loss Inspection and wall thickness measurement, Crack Inspection
EMAT	<ul style="list-style-type: none"> <li>Electro-magnetic acoustic transmission, different wave types possible</li> </ul>	Depending on configuration: Metal Loss Inspection or Crack Inspection
EC	<ul style="list-style-type: none"> <li>Traditional EC</li> <li>Magnetic-bias EC</li> </ul>	Metal loss inspection or ID/OD differentiation for Special Materials and Pipe Configurations

Table 2: Overview Inspection Technologies applied in ILI tools

# OVERVIEW - IN-LINE INSPECTION

Most ILI tools used today focus on the identification and sizing of features in the pipe wall. However it should be noted that an integrity assessment or fitness-for-purpose investigation relating to an asset containing flaws also requires accurate knowledge of material properties and local loading conditions. Apart from that there are also other features or operating conditions that influence the mechanical integrity of a given line.

Cathodic protection and the state of the coating applied to the pipe are two examples to illustrate the point. In recent years new types of ILI tools have also been introduced into the market addressing those issues, see Eiken (2016).

Figure 1 shows a tool used for the measurement of material specification of the pipe steel such as yield strength and ultimate tensile stress.

Figure 2 shows a tool utilizing electro-magnetic acoustic transmission technology (EMAT) to identify coating faults, such as disbondment.

Tools are also available today to measure parameters related to Cathodic Protection.

## THE DATA CHALLENGE

The amount of data collected during inspection has grown exponentially over the last 50 years. Data in itself however is not the purpose of an inspection. What is needed is useful information that can help to differentiate between important issues and unimportant issues. A big challenge in the future, and one that needs to be addressed by the pipeline inspection industry is to develop methodologies and technologies to turn the vast amount of available data into useful information that will add value to the pipeline integrity management process. Furthermore decision tools and effective methods of visualization must be made available.

## References

- Beller, M., Reber, K. Tools, Vendors and services: a review of current in-line inspection technologies, in: J. Tiratsoo (ed.), Pipeline Pigging & Integrity Technology, third ed., Scientific Surveys Ltd., Beaconsfield, UK and Clarion Technical publishers, Houston, TX, 2003, pp. 357-374.
- Beller, M., Steinvorste, T., Vages, S., Mastering the Inspection of Challenging Pipelines, Part 1 and 2, Pipeline & Gas Journal, October and November 2015.
- Macaw Engineering, Macaw's Encyclopaedia of Pipeline Defects, 2nd edition, 2015.
- Eiken, T., Reveal your Pipeline DNA: Uncover Pipe Grade Uncertainties with RoMat, in Proceedings, 11th Pipeline Technology Conference, EITEP, Berlin, 2016.

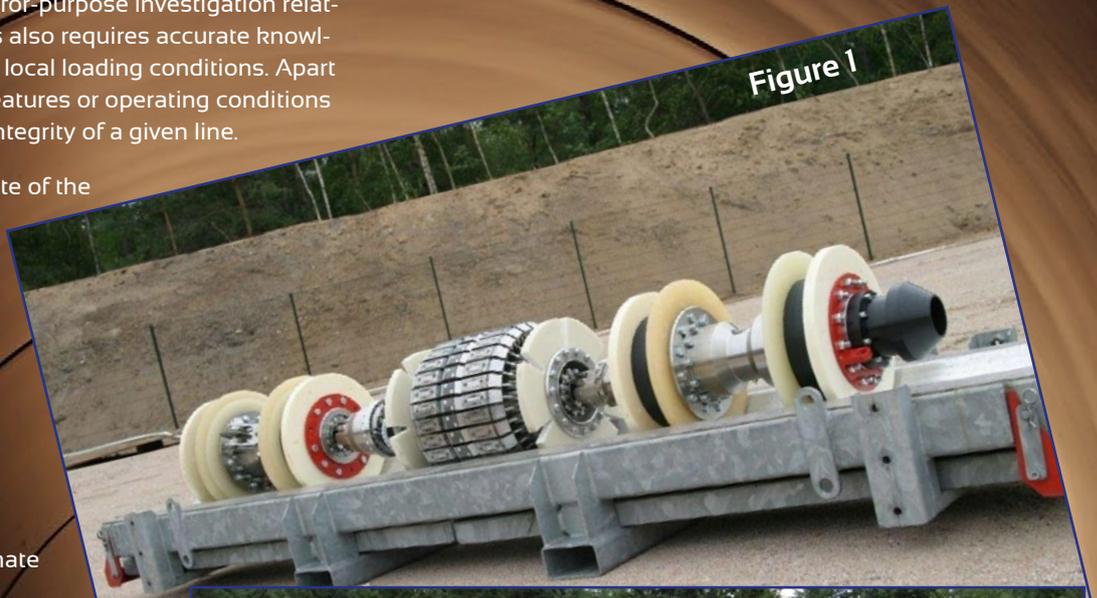


Figure 1



Figure 2

## CONCLUSIONS AND OUTLOOK

A comprehensive offer of ILI tools is available today in the market which enables the detection, sizing, locating of a wide range of flaws and anomalies in the pipe wall. In the future we will see further enhancements regarding sensitivity and sizing accuracies. Whilst mainly focusing on features in the steel body of the pipe, new generation of tools will also address the measurement of material properties and loading conditions.

In the future a major focus of development will have to address the need to handle and process increasing amounts of data in order to obtain and identify useful information. The In-line inspection industry has come a long way, but the future will bring us more exciting new developments.



# A Comprehensive Approach To Integrity Of Non-Piggable Pipelines Based On Combined DCVG/CIPS/MTM Survey

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## ABSTRACT

Integrity management of non-piggable pipelines up to now remains as an essential challenge for all Operators. For instance in Gazprom, due to diverse causes ILI technology cannot be applied for 47% of 164,7 thousand kilometers of pipelines. In addition, for half of those pipelines to run ILI is not economically reasonable.

These pipelines are primarily branch pipelines, as well as part of transmission pipelines, which were commissioned more than 30 years ago. These assets have significant value, since they deliver gas to industrial consumers and population.

Widely applicable aboveground survey techniques such as DCVG and CIPS alone, targeted at evaluation of pipeline coating integrity and CP effectiveness, do not entirely determine the integrity of non-piggable pipelines. Furthermore, these methods have limitation – they are not intrinsically sensitive to coating disbondment, which is considered as one of the significant threats to integrity.

In the meantime, over the last years Magnetic Tomography Method went through extensive industrial validation. Based on the converse magnetostrictive effect, MTM defines stress characteristics of pipe sections by registering changes in the magnetic field of the pipeline. But MTM results in low accuracy for detecting pipe features with stress level less than 5% of the SMYS (e.g., pitting corrosion).

As an effective instrument for comprehensive integrity assessment of non-piggable pipelines, authors propose to perform combined DCVG/CIPS/MTM survey, which allows to evaluate coating and pipe integrity in one-pass and compensate limitations of each method. This paper is based on DCVG/CIPS/MTM survey results of Gazprom pipelines and describes methodological approach to develop an effective pipeline integrity management plans.

## INTRODUCTION

The length of Russian gas transmission system (GTS) equals more than 164,7 thousand km [1] where large-diameter pipelines make more than half of it (1020-1420 mm) [2]. However, due to diverse causes ILI cannot be applied for 47% of pipelines. In addition, for half of those pipelines to run ILI is not economically reasonable (figure 1). These pipelines are primarily branch pipelines, as well as part of transmission pipelines, which were commissioned more than 30 years ago. These assets have significant value, since they deliver gas to industrial consumers and population. Thus, integrity management of non-piggable pipelines up to now remains as an essential challenge for all Operators, including Gazprom.

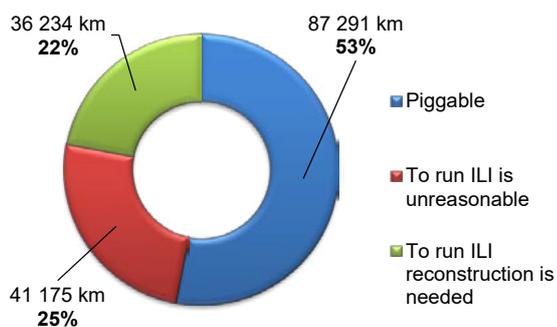


Figure 1: Total length of piggable & non-piggable pipelines in Gazprom

In this paper combination of three aboveground survey techniques (Direct Current Voltage Gradient, Close Interval Potential Survey and Magnetic Tomography Method) is described together with practical results when using the combined technique for comprehensive integrity assessment of non-piggable pipelines.

## DCVG/CIPS SURVEY TECHNIQUE

Results of the comprehensive evaluation and validation of existing aboveground techniques for coating condition assessment, carried out by various institutions (among others DNV GL) and presented in reports [for instance, 3, 4], pointed that DCVG was the most accurate survey technique, better able to resolve individual indications than the other surveys, enable to pinpoint a coating defect epicentre in the range of  $\pm 75$  mm [5].

In DCVG, when a defect is approached it will be seen on the DCVG measuring tool as a changing potential which is in phase with the applied signal. The magnitude of the swing is the potential difference between probes as a result of applied signal. Operator then locates the epicentre of the defect which is identified by a zero deflection on the meter. This occurs when the probes straddle the epicentre of the defect i.e. lie on the equipotential line of the potential field of the defect.

Once an indication is located, according to [5] its severity index (%IR) is estimated by measuring the potential difference from the indication epicenter to remote earth (OL/RE). This potential difference is then expressed as a percentage of the total calculated potential shift on the pipeline at the indication location (P/RE), as shown in equation (1):

$$\%IR = \frac{OL / RE \cdot 100}{P / RE}$$

To add value to the data collected during DCVG survey, modern digital data loggers allow to run DCVG and CIPS survey simultaneously during one pass along the pipeline route, as well as to detect defects/holidays in the pipeline coating and, most importantly, to measure the "ON" and "OFF" potentials along pipeline with step approximately 1 m, and at all defects epicentres. Thus, in addition hybrid DCVG/CIPS survey allows to determine whether the exposed pipeline wall is effectively protected by CP system. In response to hybrid DCVG/CIPS survey, the CP criteria [6] was adopted as a crucial factor for qualifying the defect as needed to be repaired.

To confirm DCVG method performance on the multiline gas transmission systems in August, 2014 AMT organized a demonstration DCVG/CIPS survey on Gazprom's gas transmission subsidiary pipelines. To participate in the project were invited two companies such as:

- Geoinvirex (Poznan, Poland) – survey company;
- Corrstop (Warszawa, Poland) – survey company.

Geoinvirex and Corrstop possesses with an enormous hands-on experience in DCVG/CIPS field inspections of pipelines within Europe and USA. It is important to indicate that companies are working with different set of equipment. Geoinvirex uses analogue DCVG-meter and digital data logger Quantum CIPS, manufactured by DCVG Ltd. (UK). Meanwhile, Corrstop performs surveys using Cathodic Technology Ltd. (Canada) tools such as Hexcorder MM, SmartLogger II, etc.

As an object of inspection Operator proposed transmission pipeline and branch pipeline, which are laid in 5-line corridor. Both pipelines were with tape coating and wrap. The total length of surveyed pipeline sections is 4'078 m.

Notwithstanding that both survey teams demonstrated one and the same method, implemented measurement schemes were distinguished and reflected the specificity of the equipment which was used by both teams. Figure one shows technological scheme used by Survey Team #1 and Survey Team #2.

The number of defects detected by each survey team on transmission pipeline is presented in table 1. Overall, no noticeable coating defects on surveyed pipeline sections were detected. According to classification given above, all of detected defects are effectively protected and fulfill the EN 12954 [6] criteria. In all five Cat. 1 defects the OFF potential is more negative than required by the standard [6].

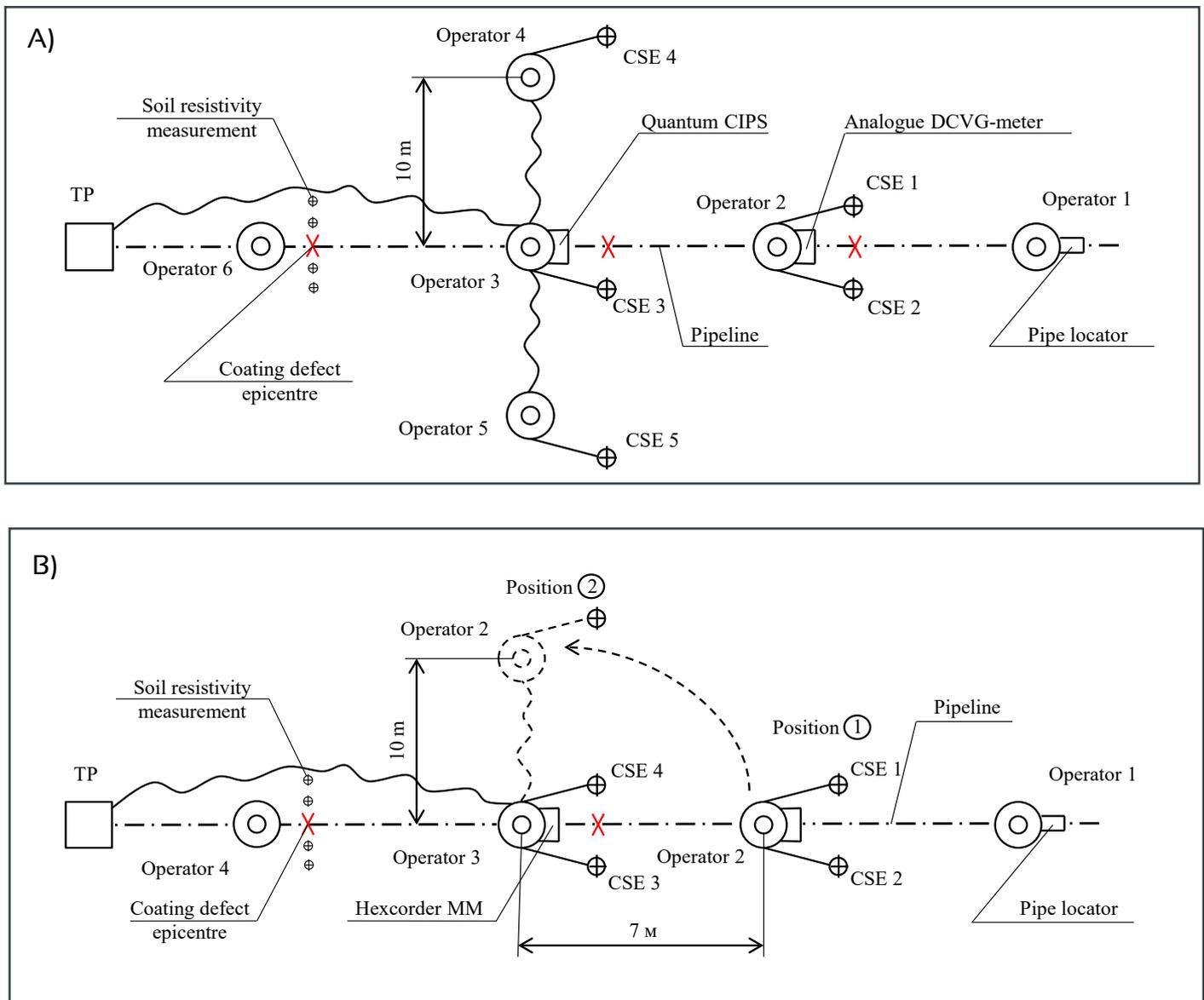


Figure 2: Technological schemes of the DCVG/CIPS survey implemented by Survey Team #1 (a) and Survey Team #2 (b)

%IR classification	Number of detected defects	
	Survey Team #1 (Geoinvirex)	Survey Team #2 (Corrstop)
Category 1 (> 35% IRrel)	5	5
Category 2 (15 - 35% IRrel)	3	14
Category 3 (<15% IRrel)	15	132
<b>TOTAL:</b>	<b>23</b>	<b>151</b>

Table 1: Demonstration DCVG/CIPS survey results on 3 km transmission pipeline

Even in the "heaviest" defect No. 60 with severity index %IR 48.16% measured potentials are: ON: -1066 mV and OFF: -909 mV. Closer comparison reveals the following:

- both teams with confidence detected defects with severity index more than 35%;
- difference between quantity of detected defects are result of higher detection sensitivity of digital Hexcorder MM tool (Survey Team #2), which is capable to localize even small size defects;
- essential disadvantage of analog DCVG meter (Survey Team #1) is a usage of peg when the defect is identified and impossibility of delivering digital data. The significance of whether a defect is pegged or not is of less importance in the case of Hexcorder MM tool (Survey Team #2) since we have a graphical records to fall back on;
- low speed performance of Survey Team #1 which approximately composed 2-3 km per day, while Survey Team #2 migrated 5-6 km per day. Furthermore, in the Survey Team #1, 6 surveyors were involved, while in the Survey Team #2, only 4.

Excavation results demonstrated on figure 3 validated the presence of coating defects, qualitative parameters (%IR) and position against the centerline as described in reports of both companies (Geoinvirex and Corrstop). Consequently, it became obvious for Gazprom that DCVG technique could be effectively applied for surveying multiline gas pipelines with extensive CP system.



Figure 3: Transmission pipeline excavation results: def. #11, diam. 120 mm (a); def. #82, 100x90 mm (b); def. #5/8, 1200x600 mm (c)

Regardless of successful results of the pilot project, DCVG and DCVG/CIPS techniques have number of limitations among which low sensitivity to coating disbondment, which is considered as one of the significant threats to integrity of pipelines, operated by Gazprom. In fact, gas pipelines with tape coating make 70-80% of total length and 95% of large diameter pipelines. Lifetime of such coating lasts only 8-12 years and most of operating pipelines exceed this age.

#### MAGNETIC TOMOGRAPHY METHOD

Magnetic Tomography Method (MTM) was developed in early 2000s and is patented in Russia, Malaysia, USA, and Canada. MTM is based on the inverse magnetostrictive effect (Villari effect) - the change of the magnetic susceptibility of a material when subjected to a mechanical stress. Method uses "natural" magnetization of the ferrous pipes by magnetic field of the Earth.

Magnetic tomography charts the attributes and characteristics of pipe sections by registering and analyzing changes in the magnetic field of the pipeline (figure 4). These changes are related to stress which in turn are related to defects in the metal. Magnetic measurements data is collected from the ground surface and anomalies detected are a function of stress, mechanical loading and structural changes in the metal.

The significant advantage of the method is that MTM does not require any preparation of the pipeline for inspection such as cleaning, opening the pipe, or interrupting pipeline operation. Magnetic field measurements are performed while pipeline operating as usual.

Evolution of this method in Russia is mostly connected with introduction of RD 102-008-2002 [7] practical guidance, developed by VNIIST (Transneft research center) in early 2000s. The practical guidance describes remote magnetometric survey procedures, requirements for equipment and survey outcomes.

According to [7] magnetic anomalies assessment is performed based on integrity index  $F$ , corresponding to extension of magnetic anomaly  $S$ ,  $m$ ; amplitude and distribution structure of magnetic field vector. Integrated index  $F$  reflects exceedance of registered values over baseline; density of peak values and their distribution pattern. The index is derived from the following equation (2):

$$F=(F+1)e^{-ka/S}$$

Where:  $A$  – number of stress concentration lines in magnetic anomaly zone;  $S$  – the length of magnetic anomaly, defined by number of measurement points of magnetic field (number of MTM scan intervals)  $m$ ;  $K$  – stress concentration ratio in magnetic anomaly zone;  $a$  – coefficient, accounting for no-failure life.

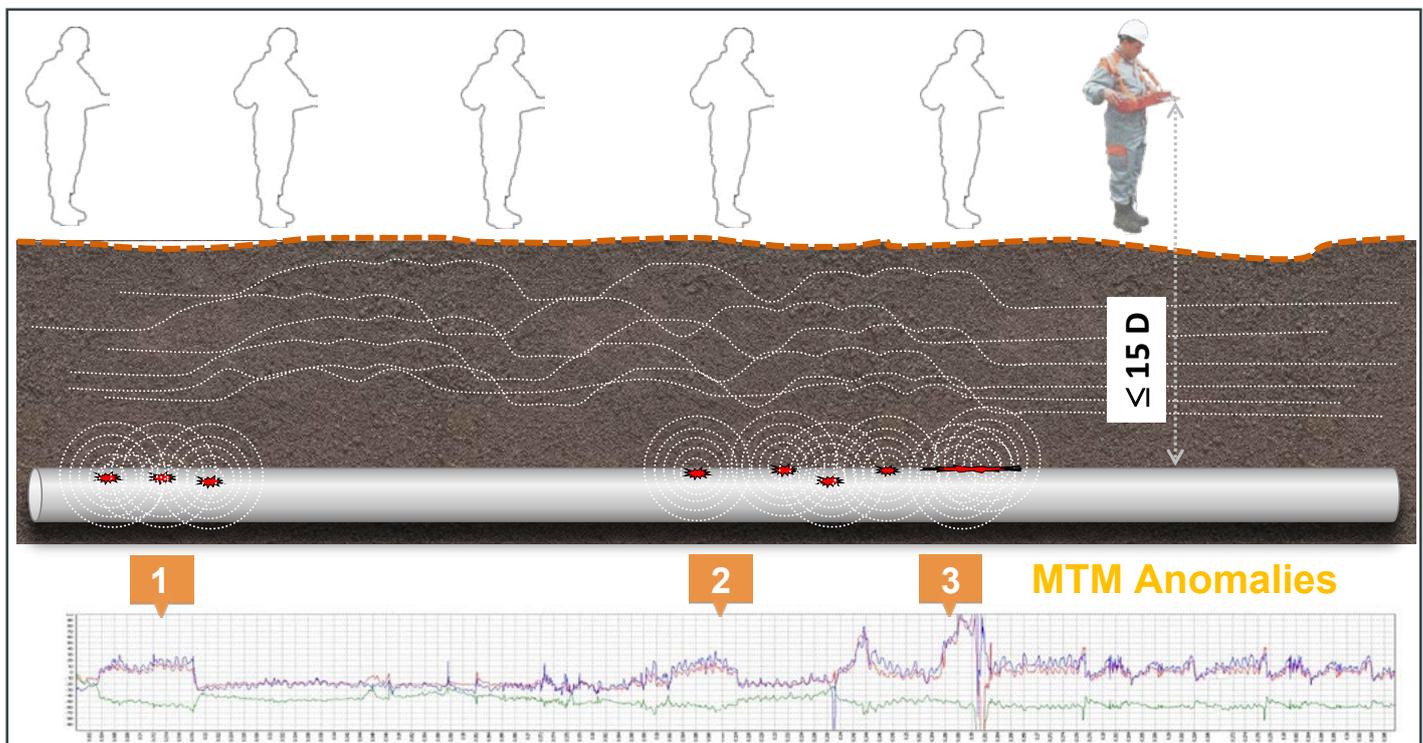


Figure 4: MTM scanning process

According to [7] MTM anomalies can be classified by three ranks depending on index F calculations as it is demonstrated in table 2.

Index F	Anomaly Rank	Assessment
$0,75 \leq F \leq 1,0$	3	APPROPRIATE
$0,45 \leq F < 0,75$	2	ALLOWABLE
$F < 0,45$	1	INACCEPTABLE

Table 2: Magnetic anomalies classification according to index F

Over the last years MTM survey technique went through extensive industrial validation on more than 17 000 km of Gazprom, Transneft, TNK-BP and Lukoil pipelines. Most remarkable were the results of branch pipeline "Kolomna-II" survey in 2014 [8]. This pipeline is operated by "Gazprom transgaz Moscow". On 2.3 km pipeline section 563 magnetic anomalies (stress concentration areas) were detected: 11 – 1st rank, 56 – 2nd rank, 496 – 3rd rank. Based on the MTM survey results operator has done 120 excavations and replaced 670 m of pipeline due to extensive corrosion damages (more than 50% of wall thickness). Data obtained during the verification on "Kolomna-II" branch pipeline enabled to calculate statistical performance parameters listed in table 3.

Performance parameter	1st rank anomaly	2nd rank anomaly
Probability of Detection POD	87%	85%
Probability of Identification POI	77%	75%
Probability of False Call POFC	9%	10.7%

Table 3: Statistical MTM performance parameters on "Kolomna-II" branch pipeline (calculated through 120 excavations)

Like any other technique, MTM has several limitations:

- Deviation if magnetometer when it far from pipeline (>15D);
- Deviation associated with residual over magnetization of pipeline due to production effects or ILI;
- Need 1-2 pits for calibration;
- Deviation generated by magnetic masses, located close to pipeline (<1D).

The most significant limitation is that MTM results in low accuracy for detecting pipe features with stress level less than 5% of the SMYS (e.g., pitting corrosion). The same pattern is observed when actual mechanical stress is more than SMYS. **In addition it should be noted, that the method to the date remains as indicative, not allowing to evaluate absolute values of stresses in pipe wall in defect area, type of a defect and its dimensions, as well as significantly depend on proficiency of data interpreter.**

COMBINED DCVG/CIPS/MTM SURVEY

Given above investigation of aboveground techniques and their inherent limitations bring AMT to present on market the combined survey technique - DCVG/CIPS/MTM - as an effective instrument for comprehensive integrity assessment of non-piggable pipelines.

Corrosion survey process using combined DCVG/CIPS/MTM technique engages five main steps: design, operation and survey data gathering; DCVG/CIPS/MTM survey; direct assessment (excavations); FFP analysis; development of rehabilitation plan. Figure 5 illustrates a typical DCVG/CIPS/MTM survey process scheme, where five surveyors are involved.

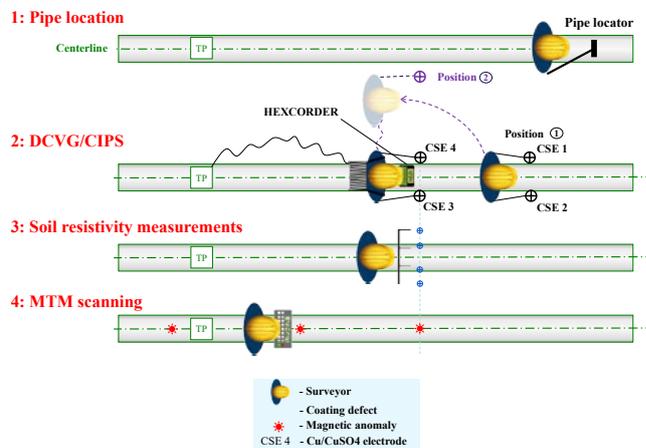


Figure 5: Typical DCVG/CIPS/MTM survey process scheme

Excavation program for pipeline direct assessment is developed based on integral parameter  $K_{\Sigma}$ , which is calculated by formula (3):

$$K_{\Sigma} = \sum G_i (I_i) \cdot \xi_i$$

Where  $K_{\Sigma}$  - integral parameter – the sum of pipeline integrity factors;  $G_i(l_i)$  – value of i-factor;  $\xi_i$  - weight coefficient of i-factor. Integrity factors and their weights are listed in table 4. The maximum of  $K_{\Sigma}$  responds to high consequences area, where excavations should be done in the first instance.

Factor	Factor Identifier	Weight Coefficient $\xi$
Coating condition (severity index %IR)	$G_n$	0,25
Ground-water level	$G_y$	0,15
Cyclic soils wetting	$G_c$	0,15
Stress condition (MTM anomaly)	$G_s$	0,15
Type of soil	$G_r$	0,10
Soil resistivity	$G_p$	0,05
CP effectiveness	$G_3$	0,15

Table 4: Factors and recommended weight coefficients according to standard R Gazprom 2-2.3-756-2013

With confidence in the accuracy of the data generated by direct assessment procedure, an operator can go forward by utilising FFP methods (RSTRENG, DNV, ANSI/ASME B31g, STO Gazprom 2-2.3-112-2007, etc.) and make decisions relating to the current and future integrity of a pipeline, remaining life assessment.

Detailed consideration of DCVG/CIPS/MTM survey data enables to identify "hot-spots", where appropriate preventative maintenance and inspection activities should be held (as it shown on figure 6).

		MTM: ANOMALY RANK				DCVG/CIPS: CP EFFECTIVENESS	
		1	2	3			
DCVG/CIPS: SEVERITY INDEX %IR	70 - 100%				No sufficient protection		
	16 - 69%						Partially cathodically protected
	0 - 15%						Cathodically protected

Figure 6: Decision matrix for developing an effective pipeline rehabilitation plan

COMBINED DCVG/CIPS/MTM SURVEY

The preceding sections summarize experience of implementation DCVG/CIPS and MTM survey techniques in Russia, where multiline gas pipeline transmission systems with extensive CP system are operated. Over the last years these two survey techniques went through extensive industrial validation resulted in proved efficiency. However, inherent limitations disable implementation of DCVG/CIPS and MTM alone to determine entirely the integrity of non-piggable pipelines.

It became the result that AMT has presented on market the combined survey technique - DCVG/CIPS/MTM - as an effective instrument for comprehensive integrity assessment of non-piggable pipelines. The results that can be achieved from this combined technique are to:

- Compensate limitations of each method;
- Provide a qualified statement on the current condition and integrity;
- Identify active degradation mechanisms and assess probable causes of corrosion;
- Recommend appropriate corrosion mitigation and control strategies;
- Calculate remaining system safe working life;
- Define effective integrity management plan (pipeline and/or coating).

For the moment, together with Gazprom the DCVG/CIPS/MTM method has been actively developed. By 2017, AMT expects that combined survey technique, as an effective instrument to maintain safety and reliability of assets, will be a part of integrity management plans of many Operators in Russia.

References

1. Akrsyutin, O.E. Better operating performance for Gazprom's gas transmission system // Gazovaya Promyshlennost' - 2010.- 03/643/2010.- p. 23-25.
2. Akrsyutin, O.E. Gas transmission system development and training engineers / O.E. Akrsyutin, A.S. Lopatin, G.G. Vasil'ev // Gazovaya Promyshlennost' - 2010.- 13/644/2010.- p. 31-35.
3. Borek, H. A practical comparison of above ground techniques for coating defect delineation / H. Borek, J.M. Leeds // Industrial Corrosion.- 1988.- March/April.- P. 14-21.
4. Ruschau, G. Evaluation and validation of aboveground techniques for coating condition assessment / G. Ruschau, A. Kowalski // Final report DTR556-05-T-0004.- CC Technologies (A DNV Company).- 2006.- 63 pages.
5. NACE Standard Practice TMO109-2009. Aboveground survey techniques for the evaluation of underground pipeline coating condition.- 2009.- 36 pages.
6. EN 12954:2001. Cathodic protection of buried or immersed metallic structures.
7. RD 102-008-2002. Guidance for pipeline inspection using remote magnetometric method.- 2002.- 53 pages.
8. Sidorov, S.A. Results of MTM survey of Kolomna-II branch pipeline / Annual Gazprom corrosion departments meeting, Sochi.- 2014.
9. R Gazprom 2-2.3-756-2013. Inspection of branch pipelines. Basic framework.- 2013.- 54 pages.

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# FLEXIBLE RISERS

## Life Extension Assessment of Dynamic Risers – a Case Study

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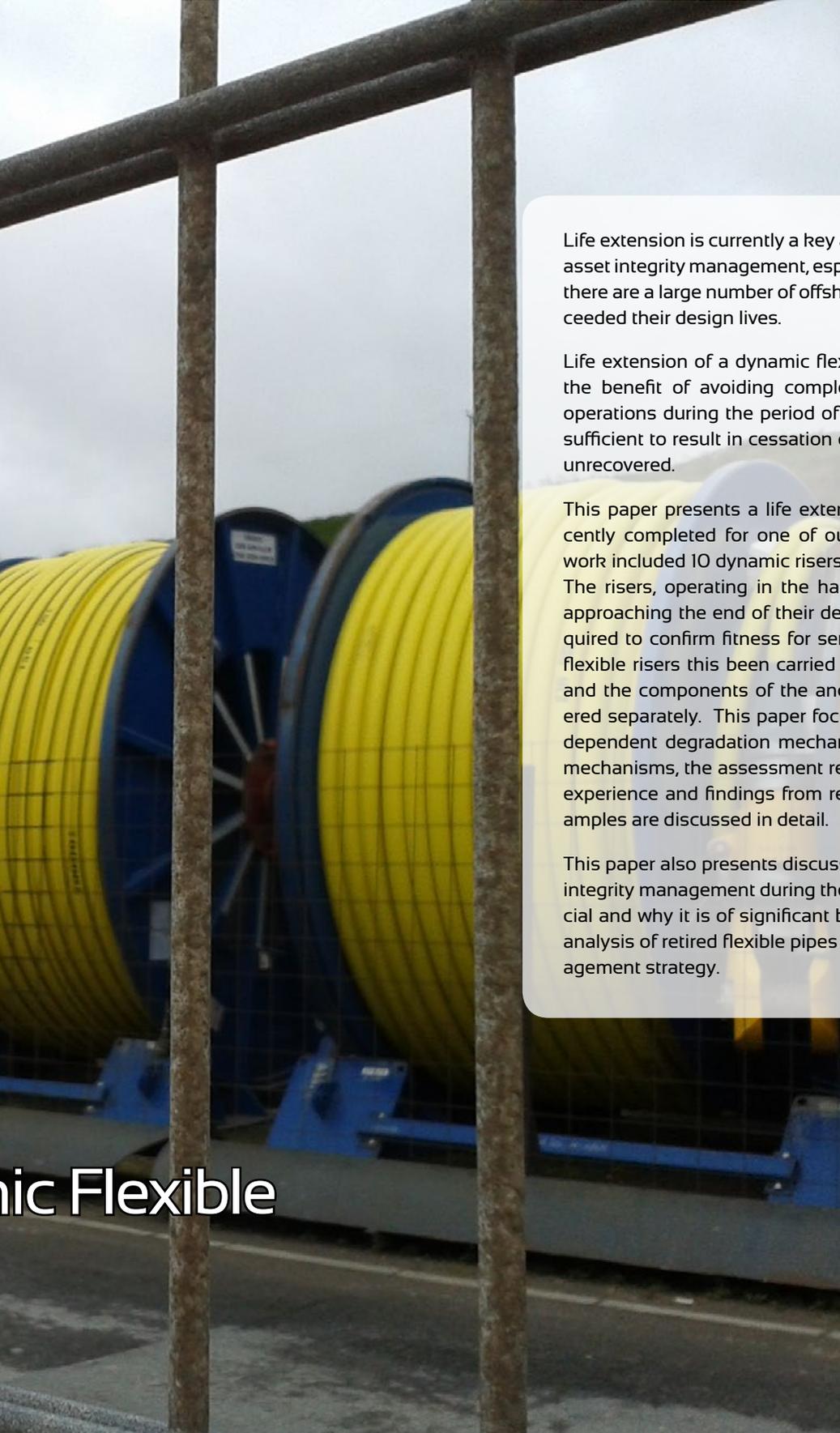
## Abstract

Life extension is currently a key area of interest in the field of offshore asset integrity management, especially in the North Sea region, where there are a large number of offshore assets approaching or having exceeded their design lives.

Life extension of a dynamic flexible riser, although challenging, has the benefit of avoiding complex and high-cost riser replacement operations during the period of extended operation, which could be sufficient to result in cessation of production and reserves being left unrecovered.

This paper presents a life extension assessment that has been recently completed for one of our main clients, where the scope of work included 10 dynamic risers and associated ancillary equipment. The risers, operating in the harsh environment in the UKCS, were approaching the end of their design life and an assessment was required to confirm fitness for service for extended operation. For the flexible risers this been carried out using a layer-by-layer approach, and the components of the ancillary equipment have been considered separately. This paper focuses on the risk assessment of time dependent degradation mechanisms. For some of the degradation mechanisms, the assessment required use of the data from industry experience and findings from retired pipe dissections, and such examples are discussed in detail.

This paper also presents discussion on why comprehensive ongoing integrity management during the period of extended operation is crucial and why it is of significant benefit to consider dissection and/or analysis of retired flexible pipes as part of the ongoing integrity management strategy.



Dynamic Flexible

## INTRODUCTION

Currently there are a large number of offshore assets in the North Sea, both UK and Norwegian Continental Shelf, which are approaching or having exceeded their design life. Due to various reasons, such as remaining recoverable reserves or enhanced oil recovery methods, there is a drive to keep some of these assets operating beyond their design life. Therefore, life extension is currently a key area of interest in the field of offshore asset integrity management.

International standards and practices governing the life extension of subsea pipelines and subsea components in the petroleum and natural gas industries make explicit reference to the expectation that continued use of a pipeline beyond its original design life requires a formal assessment to determine the condition status and any specific limitations [1, 2].

Dynamic flexible risers are one of the most challenging pipeline components when it comes to life extension assessment. This is because they are complex multi layered structures and each layer has its unique failure mechanisms (see Figure 1). Furthermore, each riser system is unique and will have bespoke ancillary equipment.

The complex structure of flexible pipes makes them very difficult to inspect and there are only a limited number of qualified inspection techniques currently available on the market, which can be used to validate the condition of the metallic layers in-situ. Therefore, life extension is mainly based on the degradation models used during design.



Figure 1: Typical flexible riser section

Design conservatism can sometimes be challenged in light of operational and industry experience, and the case study presented in this paper shows how this has been carried out for the dynamic flexible risers operating in harsh environment in the UK Continental Shelf (UKCS).

## METHODOLOGY AND SCOPE

The scope of assessment included 10 dynamic risers, in Pliant Wave™ configuration (see Figure 2), operating from a Floating Production Storage and Offloading (FPSO) vessel in the UKCS. The risers were approaching the end of their design life (25 years) and an assessment was required to confirm fitness for service for extended operation (7 years). The risers included one water injection riser, one gas riser, and eight production risers. The majority of the risers were damaged on installation and therefore had seawater flooded (wet) annuli. Also, two of the risers were replaced during the first 13 years of service.

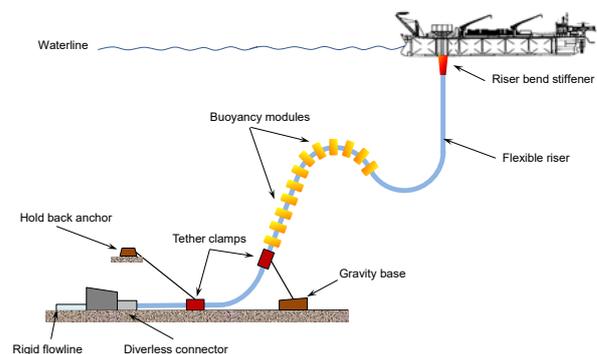


Figure 2: Typical riser layout schematic

In accordance with international standards and practices [1, 2], the life extension assessment included a gap analysis, current condition assessment, fitness for service assessment for extended operation and identification of necessary repairs and modifications to mitigate potential risks.

Fitness for service assessment for extended operation has been undertaken using a layer-by-layer approach, which considered time dependent degradation mechanisms for each layer. For some of the degradation mechanisms, the assessment required use of the data from industry experience and findings from retired pipe dissections.

## LIFE EXTENSION ASSESSMENT

**Carcass**

For the carcasses of the production risers (Duplex), erosion due to sand was considered as the dominant time dependent degradation mechanism. For the water injection riser (smooth bore) and the gas riser (Duplex carcass), erosion of carcass was not considered to be a credible threat.

At the design stage erosion calculations are normally carried out to confirm that the carcasses of the production risers will be capable of withstanding the hydrostatic pressure for the duration of the design life. When considering life extension of production risers, a good practice is to revisit the erosion calculations to account for reduced strength of carcass due to potential erosion. If, however, no changes in the flowrates and sand content are predicted and there are lessons learned from dissection of retired pipes (from the same field), a conclusion can be directly inferred without having to revisit the erosion calculations.

Data from dissection of a retired production jumper were available and showed no concerns (see Figure 3) and, because there are no industry records of flexible pipe failures solely attributed to erosion [3], it was concluded to be unlikely that erosion of carcass would be a major concern for the extended operation. However, because the gap analysis showed increased flowrates as compared to the original basis of design, and because the dissected jumper section was from a relatively straight section, there was some uncertainty associated with the risk of failure due to erosion. To address this, it was recommended to revisit the erosion calculations using the new flowrates and to consider dissection (with subsequent carcass inspection) in the event of future removal of a production flexible jumper from service, making sure that dissection is performed on a location where the jumper had a bend in service.

Carcass fatigue has been recently reported for dynamic risers removed from service in the Norwegian sector of the North Sea [4]. However, based on the riser construction, configuration and operational experience as well as the findings from retired riser dissections, failure of carcass due to fatigue was concluded to be of no concern.

**Internal Sheath**

Ageing embrittlement was considered as the dominant time dependent degradation mechanism for the production risers (Polyamide, PA-11 sheath) and the water injection riser (High Density Polyethylene, HDPE sheath). For the gas riser, ageing embrittlement was not considered a credible mechanism, because gas in the system is dry. Currently the following methods exist to assess ageing in internal sheath of flexible pipes:

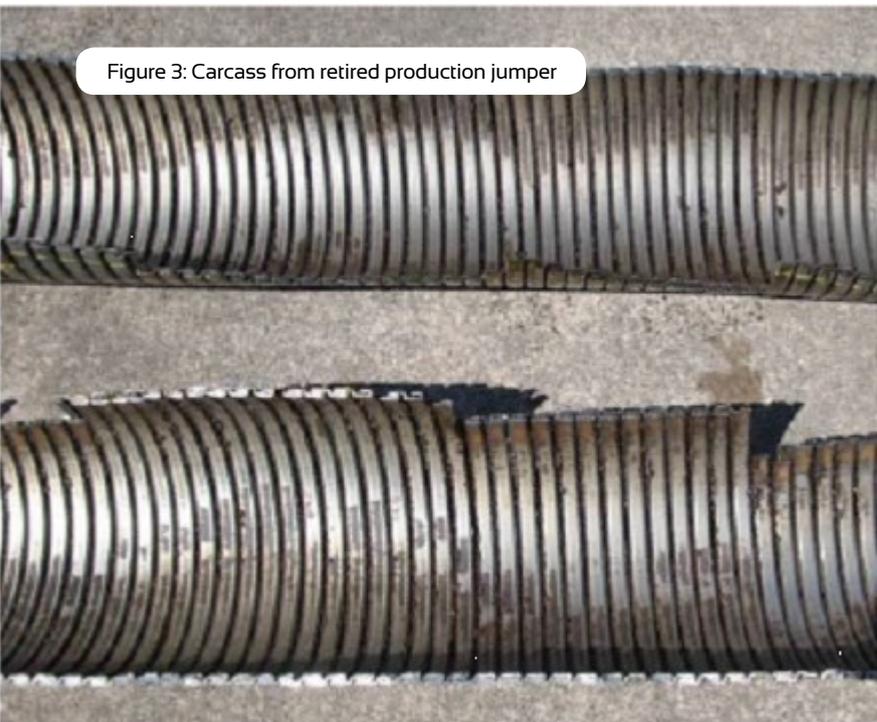
- API 17TR2 calculations based on the operating temperature (PA-11 only) [5]
- Coupon analysis: Corrected Inherent Viscosity (CIV) testing for PA-11 sheaths or mechanical testing for polyethylene sheaths [5]
- Direct assessment of sheath samples extracted from pipes removed from service, i.e. during dissection.

Direct assessment is normally used to confirm condition of internal sheath in production jumpers (pipeline hot end) because coupons installed topsides are not representative (cold end).

For the production risers, API 17TR2 calculations were carried out in conjunction with the review of the historical CIV results from the coupons. In addition, review of the direct assessment of sheath samples from a retired production jumper was carried out. Based on this, the risk of failure due to ageing embrittlement during the period of extended operation was concluded to be acceptable. However, it was recommended to revise the coupon removal schedule to ensure that there are enough coupons to cover the extended operation. The latter is important because new coupons, even from the same batch of material, will not be representative of the condition of the riser pressure sheath.

For the water injection riser, no coupons were installed topsides, which would allow validating the current condition of internal sheath (HDPE). Review of the material qualification records confirmed that the material was qualified for the design life at the design temperature; however no information was available on the predicted service life.

Figure 3: Carcass from retired production jumper



Because review of the historical monitoring data confirmed that the operating temperatures have always been compliant, it was considered unlikely that significant ageing would occur during the period of extended operation. However, because there was some uncertainty with regards to the current condition of the pressure sheath, the risk of failure due to ageing was concluded to be medium. To address this, a direct assessment of the pressure sheath from a recently abandoned water injection jumper (same pressure sheath material) was recommended.

One of the other possible time dependent degradation mechanisms is creep of internal sheath into pressure armour due to excessive temperature and pressure. This was not considered to be a credible threat for any of the risers because review of the dissection findings from the retired pipe removed from the asset with similar operating conditions showed no evidence of excessive creep (see Figure 4).

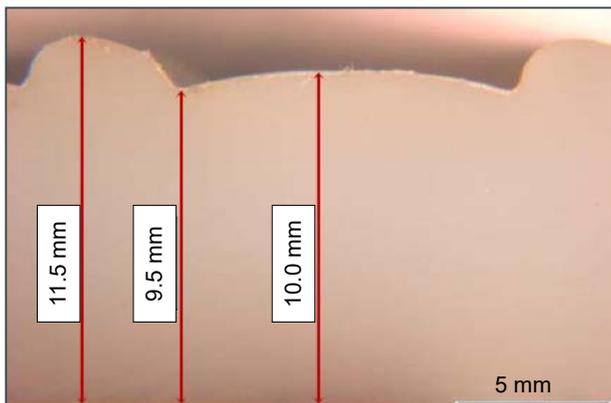


Figure 4: Profile of pressure sheath from retired high pressure (180 barg) water injection riser (5 times magnification)

### Armour Wires

Fatigue was considered as the dominant time dependent degradation mechanism for the risers with dry (non-flooded) annuli and corrosion fatigue was considered as the dominant time dependent degradation mechanism for the risers with flooded annuli. The assessment required review of the latest fatigue analysis findings, which confirmed sufficient predicted remaining service life for both flooded and non-flooded risers.

For the risers with flooded annuli (outer sheath damaged on installation), the risk of marine corrosion was mitigated by installing repair clamps at the known locations of outer sheath damage (see Figure 5), while the risk of general (CO<sub>2</sub>) corrosion was mitigated by flushing and filling the annuli with a corrosion inhibitor (shortly after damage identification).

One of the risers with flooded and inhibited annulus was replaced when in service, which was followed by dissection and testing of the metallic layers. Fatigue testing indicated fatigue life comparable to a virgin wire, which confirmed the effectiveness of the corrosion inhibitor. Furthermore, industry experience shows that for flooded flexible pipes, CO<sub>2</sub> corrosion rates in the confined annulus are minimal [6, 7]. Considering this, the risk of armour wires failure due to corrosion during the period of extended operation was concluded to be acceptable.



Figure 5: Titanium (left) and carbon steel (right) repair clamps on risers

### Anti-wear Tapes

For the anti-wear tapes (PA-II), wear and ageing embrittlement were considered as the dominant time dependent degradation mechanisms. Embrittlement is more of a concern for the risers with flooded annuli, because it requires water to extract plasticizer from the anti-wear tapes. Inspection of this layer in service is not possible and assessment relies on the degradation models and assumption used during the design, which also form input into the fatigue life predictions (friction factor).

Because ageing of the (PA-II) pressure sheath was not envisaged to be a concern during the period of extended operation, ageing embrittlement of anti-wear tapes was concluded to be of no concern. Furthermore, because inspection of retired risers operating under similar environmental conditions showed no concerns (see Figure 6), the risk of accelerated fretting fatigue due to wear of the anti-wear tapes during extended operation period was concluded to be acceptable.



Figure 6: Anti-wear tapes from retired risers (bend stiffener locations, brown discoloration is due to flooded annulus)

Outer sheath embrittlement leading to cracking has been recently reported for the risers removed from service in the Norwegian sector of the North Sea [4] (see also Figure 8 (left)). Cracking was discovered when pipes were inspected onshore following removal from service and locations were correlated with the areas of high insulation (buried segments, segments under the bend stiffener locations in air, and segments with subsea bend restrictors). Since all risers considered within the scope of the life extension assessment had bend stiffeners submerged in water, the operating temperatures were comparatively low, and onshore inspection of outer sheaths on the two replaced risers indicated no concerns, embrittlement of outer sheath under the bend stiffener area was not considered to be a credible threat.

**Outer Sheath**

For all risers, failure of outer sheath as a result of failed riser ancillary equipment was considered as the dominant time dependent degradation mechanism. In addition, failure of the outer sheath as a result of malfunctioning vent system was also considered for the production and gas risers.

Industry experience shows that failure of riser ancillary equipment can lead to damage on the outer sheath (see, for example, Figure 7). Review of the asset inspection, repair and maintenance history showed adequate maintenance of the riser ancillary equipment, while review of the current Integrity Management Strategy (IMS) confirmed adequate measures in place to mitigate against failure of the riser ancillary equipment in the future. Considering this, the risk of outer sheath failure as a result of failed riser ancillary equipment during the period of extended operation was concluded to be acceptable.



Figure 8: Example of outer sheath damage due to ageing (left, courtesy of hse.gov.uk) and abrasion (right)

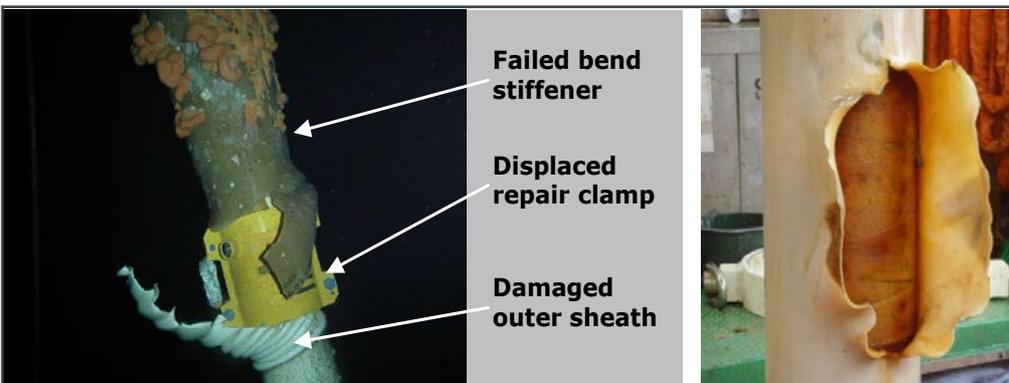


Figure 7: Example of outer sheath damage due to failed bend stiffener support elements (left) and inadequate venting (right)

Another possible time dependent degradation mechanism related to outer sheath is abrasion against I/J-tubes or seabed (touch down). Figure 8 (right) shows an example of an outer sheath damage identified at the touch down location, where riser motion caused wear of the outer sheath against the seabed. Based on the operational experience and the review of the latest inspection footage this was concluded to be of no concern.

### Vent System

Blockage and valve failure was considered as the dominant degradation mechanisms for the vent systems of the production and gas risers. Industry experience shows that blockage of gas relief valves (GRV) can occur in service [7, 8] (see also Figure 9). However, because none of the risers have GRVs fitted on subsea ends, this was not considered as a credible threat. Review of the IMS showed that the topside vent system is subject to a routine inspection and, therefore, the risk of blockage of the vent system topsides during the period of extended operation was concluded to be acceptable.



Figure 9: Marine debris identified in the GRV of retired production jumper (post retirement examination)

### Repair Clamps

The risers which were damaged on installation have repair clamps fitted at the identified damage locations. Some of the clamps are made of titanium, some are made of a composite material, and some are made of carbon steel protected with CP (see, for example, Figure 5).

For the carbon steel clamps, failure of the CP system was considered to be the dominant degradation mechanism. However, it was concluded that if and when identified, CP issues can be addressed as part of ongoing IMS and, therefore, the risk of failure of riser repair clamps during the period of extended operation was concluded to be acceptable.

Industry experience shows that some steel repair clamps may not fully seal the damage location on a riser, especially when clamps are long and fitted on dynamic sections [7]. However, because none of the risers has a repair clamp fitted on a highly dynamic section (with a low bend radius) and all clamps are relatively short in length, inadequate sealing was not considered to be a credible threat.

### Bend Stiffeners and Riser Restraining Components

For the riser restraining components, fatigue of the upper tethers clamps and gravity bases (see also Figure 2) was considered to be the dominant degradation threat. The components were chosen because it was known that they were subject to dynamic loading during operation. Corrosion was not considered as a dominant degradation mechanism because, as discussed for the steel repair clamps, any CP issues, if identified, can be addressed as part of the ongoing IMS (see, for example, Figure 10).

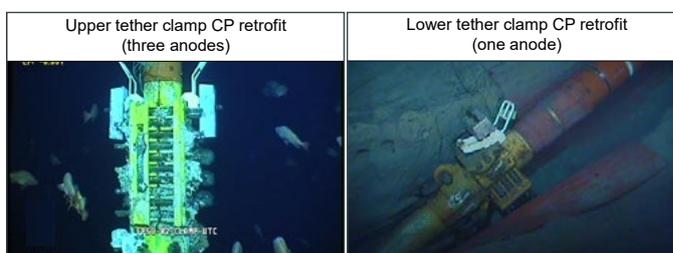


Figure 10: Retrofit anodes on riser upper tether clamp (left) and lower tether clamp (right)

Fatigue assessment of the riser restraining components was undertaken in two stages:

1. Global analysis was performed to determine the load ranges and directions imposed onto each of the riser restraining components, using the latest field metocean conditions;
2. Local analysis was performed to estimate the remaining fatigue life for the riser restraining components, using the load ranges generated by the global analysis. The assessment considered the risers which represented the worst case loading

Again, based on the assessment findings, it was concluded that the risk of failure of the riser restraining components due to fatigue during the period of extended operation was acceptable. The load ranges from the global analysis were also used to re-assess fatigue lives of the bend stiffeners. And, based on the assessment findings, it was concluded that the risk of bend stiffener failure due to fatigue during the period of extended operation was acceptable.

### Buoyancy Modules and Tethers

For the buoyancy modules and tethers, reduction in buoyancy and ageing were considered as dominant time dependent degradation threats. Because post retirement inspection and testing of the buoyancy modules and tethers from one of the replaced risers (as well as a number of retired risers from an asset operating in the same area) showed limited degradation, the risk of failure of buoyancy modules and tethers during the period of extended operation was concluded to be acceptable.

### CP System

All flexible risers will normally have CP system designed to protect armour wires from marine corrosion in case of outer sheath damage. The CP system is designed to provide protection for a limited period of time and will protect only a certain (limited) length of a flexible pipe.

Industry experience shows that, in most cases, damage to the outer sheath (main barrier) occurs during flexible pipe installation [3]. Furthermore, industry experience shows that CP will not be effective if damage to the outer sheath of a riser occurs in the splash zone area (highly oxygenated environment) [3, 7].

Considering the above, CP system retrofitting is not necessarily required to ensure fitness for service of a flexible riser for the duration of the extended operation. However, it is important to note that this implies that routine inspections (GVI/CP survey) will need to be completed on time, which will enable prompt identification and remediation of new areas of outer sheath damage.

### End-fittings

Marine corrosion was considered as the dominant degradation mechanism for all subsea end-fittings, while atmospheric corrosion was considered to be the dominant degradation mechanism for all topside end-fittings.

Industry experience shows that the Nickel based coatings, which are applied to end-fittings (both topside and subsea) during the manufacturing process, are reliable, and there is no reported failure of an end-fitting due to marine corrosion [3]. In addition, onshore inspection of the retired jumpers and risers from the field showed no concerns (see also Figure 11). Considering this, the risk of failure of riser end-fittings was concluded to be acceptable.



Figure 11: Onshore examination of a riser end-fitting

### DISCUSSION

#### Inspection, Monitoring and Testing Data

Life extension of flexible pipes is mainly based on the degradation models used during design and available data from inspection, monitoring and testing. In-service inspection of flexible risers is often limited to General Visual Inspection (GVI) because currently there are only a limited number of qualified inspection techniques available on the market, which can be used to inspect and/or validate condition of the metallic layers in-situ. The integrity of the outer sheath can be verified using riser annulus vacuum testing, which should be carried out on a regular basis. For the production and gas risers, a continuous vent gas monitoring system can be implemented; however water injection risers will still require a routine annulus vacuum test, if possible.

Data from bore fluid monitoring (temperature, pressure, H<sub>2</sub>S, CO<sub>2</sub> etc.) forms a key input into a fitness for service assessment and lack of data may introduce unnecessary conservatism. It is also important that history of repair and modifications is made available for the fitness for service assessment as this should be considered during risk assessment for extended operation.

Industry experience shows that one of the challenges is to make sure that data from inspection, monitoring and testing activities undertaken throughout operation of an asset is logged and stored, so that it is readily available when required.

## Assumptions

Some assumptions had to be made during the life extension assessment, most important of which are as follows:

1. No significant change in operating conditions will occur during the period of extended operation, i.e. the current basis of design will apply.
2. No change, i.e. reduction, will occur in terms of capabilities to monitor, assess, operate and maintain the risers during the period of extended operation. Any change in operating conditions may have an impact on the probability of some of the time dependent failure mechanisms (e.g. fatigue lives of risers, service lives of production riser pressure sheaths etc.).

Therefore, any major change in operating conditions may result in a requirement to revisit the fitness for service for extended operation. This is of particular importance when the scope of assessment includes dynamic flexible risers with flooded annuli, especially when reservoir souring is predicted during the further operation period. Therefore, a comprehensive ongoing integrity management during the extended operation is crucial.

Industry experience shows that temperature and/or pressure sensors can fail in service, and the probability of failure increases over time. Such events, if they occur, will need to be addressed as soon as practically possible or otherwise a lack of data will introduce uncertainties into the integrity status of the pipes. In addition, for high pressure risers, fatigue lives will be significantly reduced if annuli become flooded and, therefore, regular annulus testing will be required to ensure continuous fitness for service during the extended operation.

## Lessons Learned

Assessment of some of the time dependent degradation mechanisms requires a good understanding of the specific flexible pipe design system and configuration as well as a good awareness of previous failures reported in the industry. In addition, each riser system has bespoke ancillary equipment. Therefore, life extension of dynamic flexible risers requires specialist knowledge.

For some of the time dependent degradation mechanisms, the fitness for service assessment for extended operation required the use of data from industry experience and findings from retired pipe dissections (i.e. lessons learned). Therefore, it is of significant benefit to consider dissection and analysis of retired pipes and post retirement testing of retired riser

ancillary equipment as part of the IMS. The costs associated with such inspections and testing may be low when compared to the potential savings offered by the use of the lessons learned from dissections findings for both the ongoing fitness for service assessment and the assessment for extended operation.

## Ancillary Equipment

It is important to include riser ancillary equipment in the fitness for service assessment for extended operation. This is not only because ancillary equipment, when present, forms a key part of a flexible riser system, but also because some ancillary equipment cannot be easily repaired or replaced in-situ. For a riser operating in deep waters, such examples include a bend stiffener and a subsea diver-less connector (Figure 12).



Figure 12: Riser bend stiffener (left) and diver-less subsea connector (right)

If riser ancillary equipment (tether systems) includes mooring type components (masterlinks and shackles) made of carbon steel, which are subject to cycling loading and have no CP protection, then fitness for service for extended operation may prove difficult. The dominant time dependent degradation mechanisms for such components in service are corrosion and wear. Both result in reduced capacity due to reduced cross sectional area, while corrosion (pitting) may also result in irregular surface which will lead to accelerated fatigue. At present there is little data available which indicates how the break strength of long term deployed mooring components will be reduced by wear, corrosion including pitting, and the possible development of small fatigue cracks [9]. In accordance with the API RP 2I, masterlinks and shackles on a mooring chain should be removed from service if a diameter in any direction is less than 10% of the nominal diameter, or there are surface cracks that cannot be eliminated by surface grinding [10]. While there are techniques on the market that allow in-situ measurement of the chain component, inspection of mooring components in water is difficult, particularly with respect to identifying possible cracks [11].

## Other Considerations

It is a standard assumption that transfer of knowledge from retired personnel and during change of ownership will occur. However, experience shows that this is not always the case and, therefore, some measures have to be in place to address this risk.

Life extension of a dynamic flexible riser, if executed on time, has the benefit of avoiding complex and high-cost riser replacement operations during the period of extended operation, which could be sufficient to result in cessation of production and reserves being left unrecovered.

Change in environmental conditions should be considered during the life extension assessment, and is normally carried out as part of a gap analysis. The data in the public domain suggests increased wave and heights for selected areas of the North Sea [4]. This will have an impact on the riser response and fatigue life, which will affect the remaining service life predictions.

Currently, polymer service life predictions (ageing) can only be carried out for PA-II material [5]. Condition assessment of other materials requires presence of coupons topsides from the first day of system commissioning. Therefore, it is important to consider this at the design stage, as otherwise there may be a requirement to remove one of the jumpers from service in order to validate condition of the pressure sheath.

In accordance with the update to the Safety Case Regulations in 2006, in the UK, there is an explicit requirement to submit a revised safety case to the Health and Safety Executive (HSE) when material changes to the previous safety case have occurred (which includes life extension and introduction of new activities) [12]. The latter implies that a life extension assessment should be followed by a review and revision of an asset safety case. In Norway there is a requirement for an operator to get approval from the Petroleum Safety Authority (PSA) to operate beyond the original design life [13].

## CONCLUSIONS

Flexible risers are complex multi layered structures and life extension requires specialist knowledge. It is important to consider riser ancillary equipment during life extension assessment, because it forms a key part of a flexible riser system and some components cannot be easily repaired or replaced in-situ. Design conservatism can sometimes be challenged in light of operational and industry experience, and the case study presented in this paper shows how this has been done for the dynamic flexible risers operating in harsh environment.

Life extension of a dynamic flexible riser has the benefit of avoiding complex and high-cost riser replacement operations during the period of extended operation, which could be sufficient to result in cessation of production and reserves being left unrecovered.

For some of the degradation mechanisms, the fitness for service assessment for extended operation requires use of the data from industry experience and findings from retired pipe dissections. Therefore, it is of significant benefit to consider dissection and/or analysis of retired pipes and post retirement testing of retired ancillary equipment as part of the integrity management strategy.

Comprehensive integrity management during the period of extended operation is crucial because any major change in operating conditions may result in a requirement to revisit the fitness for service for extended operation. This is of particular importance when the scope of assessment includes dynamic flexible risers with flooded annuli and reservoir souring is predicted during the further operation period.

## References

- [1] Life Extension of Transportation Systems, NOR-SOK Y-002.
- [2] Ageing and Life Extension for Offshore Facilities in General and for Specific Systems, Sintef Report A15322.
- [3] SureFlex JIP Report "State of the Art Report on Flexible Pipe Integrity", WGIM/MCSK Doc. No. 2-4-5-013/SROI, Rev. 02, 26/08/2010.
- [4] Petroleum Safety Authority Seminar on "Flexible Risers – Management of Integrity, Learning, Sharing of Experiences and Continuous Improvement", Stavanger (Norway), 26/11/2013.
- [5] API TR 17TR2 "The Ageing of PA-II in Flexible Pipes", 01/06/2003.
- [6] OMAE2003-37473: Clements R., Ethridge A. "Corrosion Testing of Armour Wire in Simulated Annulus Environments of Flexible pipelines - An update", Offshore Mechanics and Arctic Engineering 2003.
- [7] D. Tadjiev "Dissection and Analysis of Retired Flexible Pipes – Key Findings and Lessons Learned", paper preparation in progress.
- [8] "Riser End of Life", JIP Report, Flexlife Ref. FLX-JIP-001, Rev. 03, 30/05/2013.
- [9] C. Morandini and F. Legerstee "Consistent Integrity of Mooring System", Proceedings of the 19th IOPEC 2009, pages 625-632.
- [10] In-Service Inspection of Mooring Hardware for Floating Drilling Units, API RP 21, 2nd Ed., November 1996.
- [11] JIP FPS Mooring Integrity, Report No. A4163/MGB/REV.1, 21/12/2005.
- [12] A. Steacey and M. Birkinshaw "Life Extension Issues for Ageing Offshore Installations" OMAE2008-57411, 2008.
- [13] Petroleum Safety Authority "Regulations Relating to Material and Information in the Petroleum Activities", 2001.

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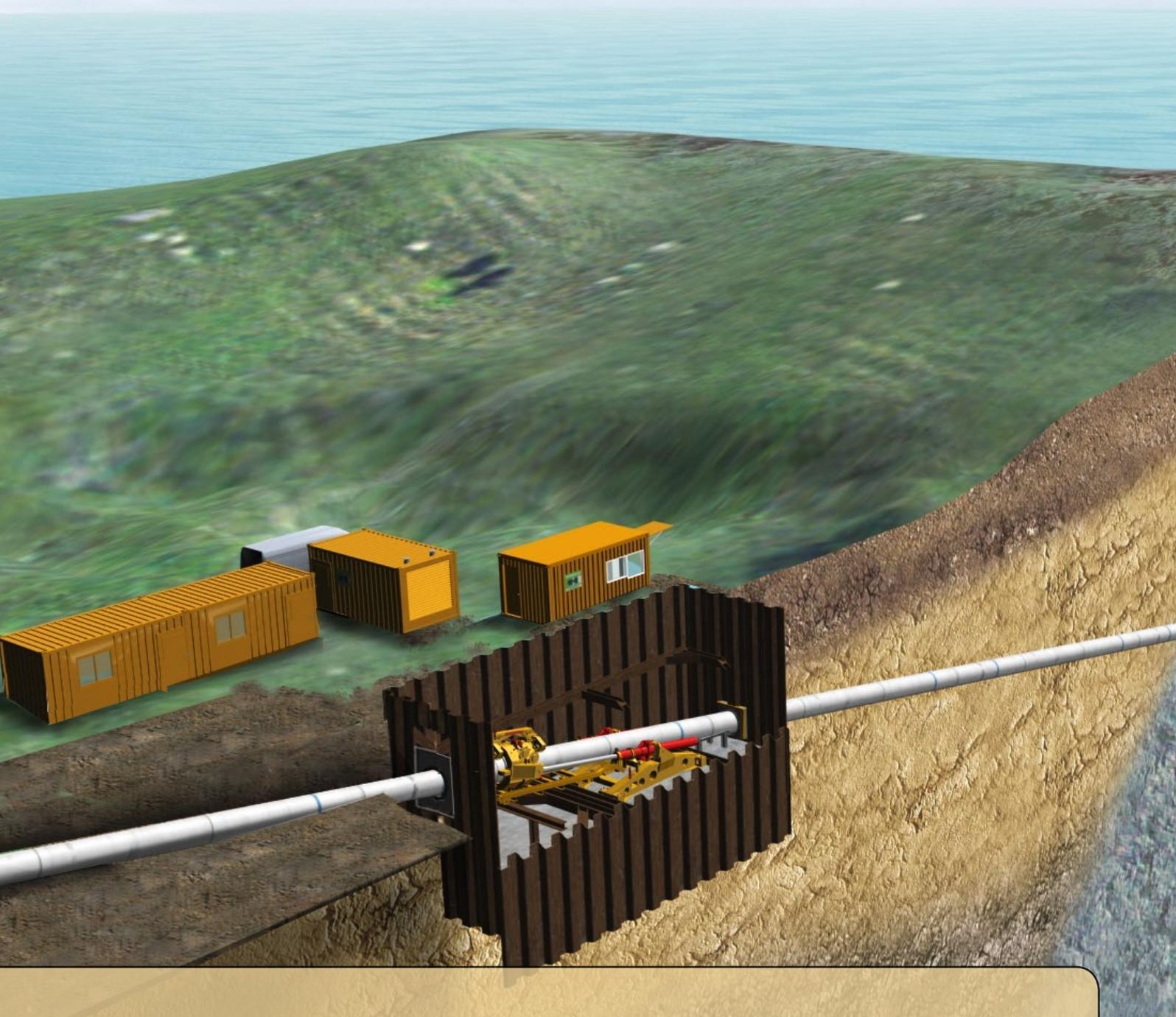
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# VARIETY OF TRENCHLESS TECHNOLOGIES FOR PIPELINE INSTALLATION

## ABSTRACT

In pipeline construction, occurring surface and sub-surface obstacles such as waterways, roads and underground installations or environmentally sensitive areas have to be crossed. These obstacles require specialized construction techniques with minimum environmental impact. In the planning stage of a pipeline crossing project, all surrounding conditions have to be analyzed to find the safest and most costefficient method to be deployed.

Besides technologies made especially for the pipeline industry, e.g. HDD, there is a growing number of alternative pipeline installation methods, which partly come from the tunneling industry. Whereas some of the technologies install the product pipeline directly into the borehole (e.g. HDD, Direct Pipe<sup>®</sup>, Pipe Express<sup>®</sup>), others install casings in which the pipeline is pulled-in in a further step, e.g. by a Pipe Thruster.

In most cases, pipeline casings are installed using Pipe Jacking and Segment Lining Tunnelling equipment, depending on crossing length, diameter and geology. By using Pipe Jacking equipment, it is also possible to jack steel product pipes through the ground. In this case, welding of the steel pipes has to be carried out during the pipe jacking works.

Direct Pipe<sup>®</sup> combines the well-established Slurry Microtunneling Technology with the Pipe Thruster Technology. It is ideal for pipeline river crossings where HDD is too risky to apply. PipeExpress<sup>®</sup> is a semi-trenchless installation method with minimum impact on the surface. In comparison to the conventional cut and cover method Pipe Express<sup>®</sup> only requires approx. 30% of the right of way. Thereby less top soil needs to be removed, less trees cut and most importantly less precious farmland is being affected by the installation method.

This paper presents the alternative trenchless construction methods for pipeline crossings. Several selected case studies prove the wide application field of trenchless techniques for the pipeline industry.



by:

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INTRODUCTION

Open-trench construction methods are commonly the most efficient and fastest pipeline construction methods for cross-country pipeline installations. But in most pipeline projects it is not possible to trench the whole pipeline route. Hence, it will be probably necessary to cross occurring surface and sub-surface obstacles along the route. Possible obstacles are:

- Traffic infrastructure: roads, railways
- Utility lines: cables, other pipelines, sewage and water networks
- Waterways: canals, rivers, coast lines
- Topographical conditions: mountains, inclinations
- Buildings
- Environmentally sensitive or protected areas

Each of these obstacles requires specialized construction techniques to be crossed with minimum environmental impact. This chapter presents alternative trenchless pipeline construction methods to cross obstacles on the route in a safe, effective and environmentally acceptable manner.

TRENCHLESS CONSTRUCTION METHODS

Besides technologies made especially for the pipeline industry, e.g. Horizontal Directional Drilling (HDD), there is a growing number of alternative pipeline installation methods, which partly come from the tunnelling industry. As the pipeline industry generally requests a high level of accuracy of the final pipeline location, this chapter only considers pipeline installation technologies to fulfill this requirement. In the planning stage of a pipeline crossing project, all surrounding conditions have to be analyzed to find the safest and most cost-efficient method to be deployed. This detailed analysis is the most important factor for later success of the chosen installation technology.

Whereas some of the technologies install the product pipeline directly into the borehole (e.g. HDD, Direct Pipe®), others install casings in which the pipeline is later installed. Pipe Jacking also offers the possibility to jack steel product pipes through the ground. In this case, welding of the steel pipes has to be carried out during the pipe jacking works.

Table 1 gives a preliminary overview of the installation technologies described in this paper. Figure 1 and figure 2 show only a rough tendency to compare the different trenchless technologies in regards of cost and risk. Final figures may vary with specific project conditions.

Construction Methods	Casing Construction	Direct installation of product pipeline / Steel pipes
HDD		
Pipe Jacking		
Segment Lining		
Direct Pipe		
Pipe Express		

Table 1: Overview of trenchless pipeline installation methods

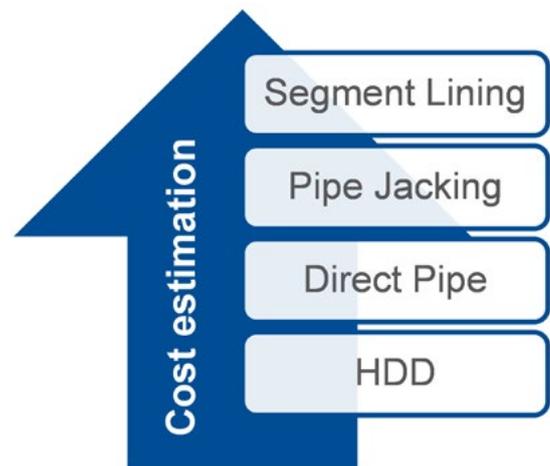


Figure 1: Overall estimated cost relation of trenchless pipeline installation technologies

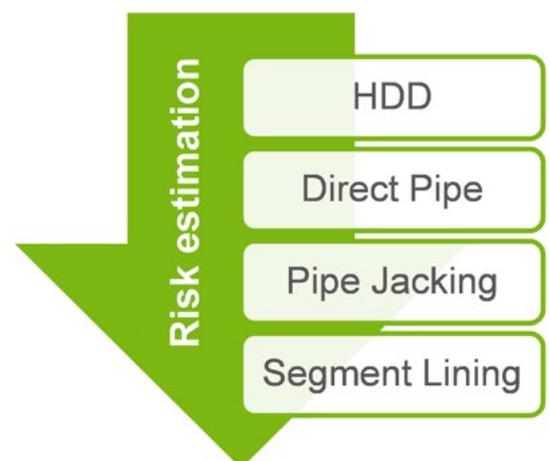


Figure 2: Overall estimated risk relation of trenchless pipeline installation technologies

## TUNNELING

Once the decision has been taken to use a tunneling technology for a trenchless pipeline crossing, the suitable tunneling machine concept has to be chosen. Within this process, the detailed analysis of the geotechnical report is the most important decisive factor. In most cases, Pipe Jacking and Segment Lining would present a casing construction and hence install the product pipeline as the tunnel is constructed. For Pipe Jacking, especially in smaller diameters up to ID 1,200mm, it would also be possible to use steel pipes. This would mean that the pipeline is not prefabricated in long pipe sections, but that shorter pipes have to be lowered in the launch shaft and welded prior to being jacked forward. In such cases, the pipeline coating must be adequately designed to withstand the potential abrasiveness.

### a) Pipe jacking

Pipe jacking is a method of constructing tunnels and underground pipelines. Pipes are jacked by hydraulic jacking cylinders from a launch shaft into the ground to a reception shaft. Thereby simultaneously the excavation of the ground material at the face and the conveyance of the muck are effected.

The jacking station has to be installed in the launch shaft and adjusted in direction, height and pitch. Then, the tunnelling machine has to be arranged in the jacking station and the jacking cylinders are extended. The tunnelling machine is pushed into the ground and at the same time the rotating cutting wheel of the machine excavates the ground material. The advance stops, when the maximum stroke of the jacking cylinders is reached. The cylinders are retracted and a new pipe is to be installed in the jacking station. Then the jacking cylinders

extend anew. This cycle has to be repeated until the tunnelling machine runs into the reception shaft. There the machine has to be recovered.

The remote-controlled microtunnelling machines are operated from a control panel in a container which is located on surface next to the launch shaft. This is an advantage regarding safety regulations, because no staff has to work in the tunnel during construction. The position of the remote-controlled machine is monitored by a guidance system. Today, the developed tunnelling technique enables the realization of long distance advances, also in difficult ground conditions.

### b) Reference Project Pipe jacking

#### Cologne / Germany

In addition to extending pipeline networks, new power stations are being built or existing ones modernized to make them fit for the needs of the future. Connecting two refinery locations near Cologne to make better use of synergies was the goal of the client, planning a four kilometer long pipeline for the transport of different fluids from one refinery to the other, located directly at the Rhine River. Along the route, the pipeline crossed the Rhine River twice, whereas the medium section was installed by open-trench methods. Two AVND2000 (ID2000mm) machines were used to install the pipe jacked casing of respectively 1,300 and 1,200 meters, in up to 15 meters depth below the riverbed. The trenchless installation of a casing tunnel to host the pipeline bundle presented the safest solution during construction as well as for later operation of the pipelines.



Figure 3: Schematic view of an AVN/slurry machine jobsite for Pipe Jacking



Figure 4: AVND 2000 and jacking cylinders installed in the launch shaft



Figure 5: Pipeline bundle installed in the pipe jacked tunnel

### c) Segment lining

Segment lining is a tunnel construction method used mainly for longer drive lengths, drives with multiple curves and larger tunnel inner diameters. The tunnel is constructed of rings which in turn are comprised of individual segments. For large diameter tunnels, segments facilitate the handling of the tunnel lining substantially in comparison, for instance, to individual pipes, which, depending on the location, can pose logistical challenges over ID4000.

The tunnel lining is assembled in the protected rear section of the TBM called the tailskin. After one complete ring is installed, thrust cylinders in the TBM thrust module push against the installed ring moving the TBM forward for the next excavation cycle. Depending on the type of TBM the excavated material is transported to the surface by rail-bound locomotive system with muck cars, tunnel belt conveyor, slurry fluid transport system or rubber wheeled multi service vehicle (MSV).

### d) Reference Project Segment Lining

#### Aughoose, Ireland

A 83 km long gas pipeline links the Corrib gas field to the Bellanaboy bridge gas terminal in the county of Mayo, Ireland. On a 4.9km long section the pipeline had to cross Sruwaddacon Bay. Due to environmental and safety benefits, the client decided to construct a segmentally lined casing tunnel to host the 20" gas pipeline. The AVND 3500 which was used to build Europe's longest segmentally lined gas tunnel of 4,893m length, installed a total of 25,000 segments in a changing geology from hard rock to sand. After installation of the pipeline in the tunnel, followed by testing, the tunnel was backfilled with a grout mix to seal it.

### e) Special applications in tunneling

Pipelines installed underground are indispensable for supplying the growing world population with water, oil, gas and electricity, for removing wastewater and to provide functioning telephone and communications networks. During the recent years, the limits of trenchless applications have been permanently shifted. This led to higher and stronger project requirements which partially had to be answered by new technologies; either as further development of existing methods, or by development of new methods taking some

elements of proven technologies into consideration. Trenchless pipeline installation methods are used for different kind of special applications: e.g. Sea Outfalls/Pipeline landfalls, Blindhole applications and in projects with high groundwater pressures.

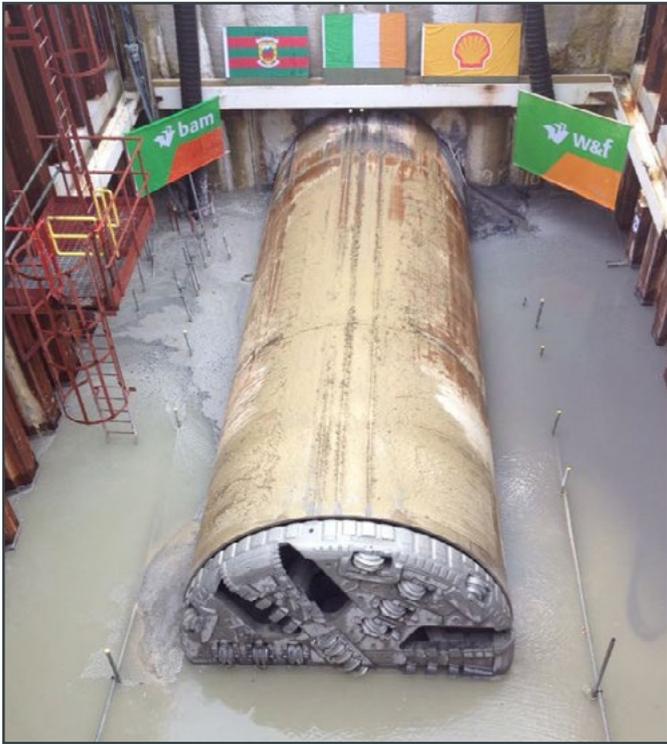


Figure 6: Breakthrough of AVND3500 machine in target shaft

#### f) Sea Outfalls

The worldwide growing demand for oil and gas makes the construction of pipelines on- and offshore necessary. Sea outfalls, seawater intakes and pipeline landfalls may generally be installed by trenchless or open-cut trenching methods. In comparison to open-cut methods of pipe installation, trenchless installation techniques reduce impact on environment to a minimum. The trenchless technologies HDD, Tunnelling, Direct Pipe® offer technical solutions to execute on-offshore connection lines or outfall and intake structures.

The installation takes completely place underground, without harming the marine wildlife. Sea water quality remains untouched, emissions and vibrations caused by the pipeline installation are considerably reduced. Trenchless marine pipeline installation can also be applied in densely populated areas, where only little space is available for jobsite installation. Due to the displacement of the "jobsite" underground, life in coastal areas can continue, tourism and shipping traffic is not affected. Existing pipe networks can be conserved. The installation works of a pipeline underground do hardly depend on external

conditions like the weather, storms, ebb and flood or sediment transport. This makes the trenchless technology a safe and reliable construction method. In the long run, the installation underground even extends the pipeline life cycle, the pipeline remains protected underground against damage by ships or sabotage, with a lower risk of settlement and a higher seismic safety.



Figure 7: View on the jobsite installation of a pipe jacked outfall tunnel

#### g) Pipe Thruster – Pipeline installation in casing tunnel

Pushing pipelines into existing tunnels (created by Pipe Jacking or Segment Lining technology) with the Pipe Thruster becomes more and more common in the pipeline industry. This method has already been implemented in several projects worldwide. On a large gas pipeline crossing in Australia, a 750 t Pipe Thruster was used to install the 4,35km long pipeline in a segmentally lined tunnel. As the tunnel was completely flooded to host the pipeline, no additional installations in the tunnel were necessary. The pipeline was pushed in within 14 working days. Currently, this is the record length of a pipeline inserted by the Pipe Thruster.



Figure 8: Pipe Thruster installing a concrete coated 42" pipeline into an existing tunnel in Australia with a length of 4,35 km



Figure 9: A special Pipe Brake installed at the tunnel entrance to hold the pipeline when the clamping unit of the Pipe Thruster is opened

#### HORIZONTAL DIRECTIONAL DRILLING

In the HDD method, pipelines are laid in three stages. First, a pilot drill is carried out from the launch point, using rotating drilling rods. The excavated material is transported to the surface by the drilling fluid which also gives the chisel extra drive. In the second phase, the retraction of the drilling pipeline, the excavating diameter is gradually enlarged with a reamer. In most cases, the borehole is supported by a bentonite suspension which at the same time serves as the transport medium for the excavated material. Finally, the pipeline is installed by pullback of the pipeline. This method is suitable for diameters of up to 56 inches (approx. 1.5 meters) and for lengths of up to around 3,000 meters, depending on the diameter. Drilling in less stable geologies, such as gravel, is not always possible because, unlike in the pipe jacking or segmental lining methods, the drill hole is not immediately stabilized.

##### a) HDD application for landfall - shore approach

Horizontal Directional Drilling method can also be applied for seawater intakes, outfall lines and landfalls for oil, gas or telecommunication pipelines. There are several options regarding construction method and drilling direction depending on diameter and length of pipeline and geological conditions.

Horizontal Directional Drilling can be considered as a very flexible construction method for connection lines between land and sea bottom. The HDD-Rig can be positioned on the onshore jobsite or offshore on a barge, a jack-up platform or cofferdam. To increase flexibility, a Pipe Thruster can be used to generate additional thrust force to push longer or larger pipes. According to the circumstances onsite, the pipeline can be prepared onshore or floating on the water. The final design of a landfall installed by HDD depends on the project requirements and conditions.

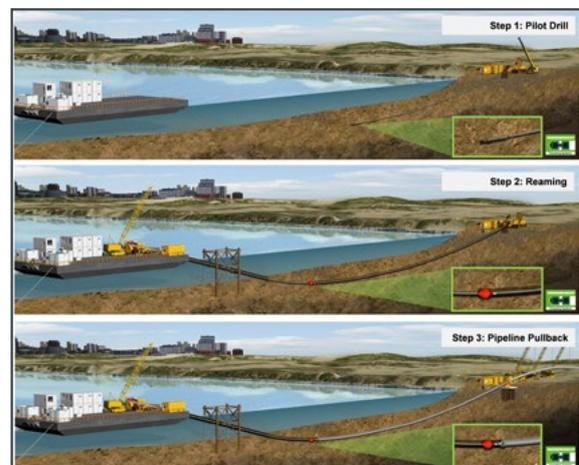


Figure 10: HDD Drilling steps for landfalls

## b) Reference Project HDD

## Barrow Island, Australia

By the year 2014, Australia will cover 8% of the global demand for liquefied gas. The Gorgon Joint Venture (Chevron, Exxon-Mobil, and Shell) is developing the Greater Gorgon Area gas fields, located approximately 130km off the north-west coast of Western Australia in Commonwealth waters. These gas fields contain some 40 trillion cubic feet (Tcf) of gas, the nation's largest undeveloped gas resource. The exploration of the huge deposits of Great Gorgon close to Barrow Island is currently the largest recovery project of liquefied gas worldwide. Offshore pipeline systems and industrial exploration plant have to be built. The Gorgon gas fields are linked by submarine pipelines to the north west coast of Barrow Island. The Island is a Class 'A' Nature Reserve for the purpose of 'Conservation of Flora and Fauna', which represents the highest level of protection afforded under State legislation. Barrow Island is home to at least 22 unique terrestrial species and is also a significant nesting site for marine turtles. Therefore, the Gorgon Project underwent stringent environmental assessment prior to obtaining approval to proceed with the development in 2009. The State and Federal Governments have put in place a range of measures to protect the environment and ensure the highest environmental standards are met throughout the life of the project. This entails strict environmental management practices for both operations and mobilisation of personnel and equipment to site.

To match these requirements in this sensitive area, AJ Lucas Group provided two Herrenknecht HDD-Rigs (HK400M & HK250T) to execute the directional drilling of nine 450-520 metre long HDD holes, including the stringing, welding and NDT testing of the pipelines. Besides three 34" landfalls for high pressure LNG flowlines, the rigs installed 6 landfalls (6 to 10") for utility lines supplying water, electricity etc. to the plant. Due to the drilling through fractured sandstone and calcarenite with up to 70MPa compression strength. A 500to Pipe-Thruster (HK500PT) has been used to install the pipes from land to the sea. Off shore diving vessels were used to guide the pipelines beyond the exit of each HDD hole to the target lay down area.



Figure 11. Pipe Thruster in operation to install supply line

## DIRECT PIPE®

The Direct Pipe®-method for trenchless installation of prefabricated steel pipelines combines microtunnelling technology of excavation with a thrust unit, the so-called Pipe Thruster described above. Direct Pipe® incorporates the advantages of microtunnelling which enable application in difficult ground conditions, while reducing risks to a minimum. This opens up new application potentials.

Originally developed as an auxiliary tool for the pullback of the pipe in the HDD method, it was presented for the first time at the Hannover Fair in spring 2006. The Pipe Thruster embraces the prefabricated and laid out pipeline and pushes it into the ground in strokes of five meters each. The requisite bore hole is excavated by a slurry microtunnelling machine (AVN) which is mounted at the front of the pipeline.

This method allows the excavation of the borehole and the simultaneous trenchless installation of a prefab and tested pipeline in one single continuous step. Similar to pipe jacking, the soil is excavated with a Herrenknecht microtunnelling machine. The position along the specified tunnel route is monitored by state of the art techniques of controlled pipe jacking. The excavated material is removed through the slurry circuit placed in the prefab pipeline. The forces which are necessary for pushing the pipeline ahead are exerted by a novel push mechanism known as the Pipe Thruster, an innovation of Herrenknecht AG. The Pipe Thruster operates like the jacking frame used for jacking concrete pipes and transmits the push forces to the cutterhead via the pipeline.

Just like the microtunnelling method, prior to launching the machine is positioned at the requisite access angle on a launch rail in front of the launch seal. The pipeline is welded to the conical rear section of the machine and mounted on rollers behind the launch pit. The clamping unit of the Pipe Thruster embraces the pipeline and thrusts it into the ground along with the machine. The current maximum pipeline diameter which can be clamped is 60" (OD = 1524 mm). The forces to be

anchored depend on the pipeline access angle and the maximum thrust force to be applied. This technology can be used also for the application of Sea Outfalls or Intakes. Due to the pullback option of the whole pipeline in case of non-destructible obstacles, the geological risk is minimised.

## Reference Project Direct Pipe®

## Port Arthur, USA

The project was part of a larger water delivery infrastructure upgrading program for the city of Port Arthur, TX. This program was driven by the US economy turning from a natural gas importer into a gas exporter. The Houston based Cheniere Energy company therefore decided to upgrade their refinery capacity in their Port Arthur facility. In order to cope with the higher water demand a 25mile long, 36" HDPE water transmission main had to be constructed including the crossing of the environmentally sensitive Sabine Neches Waterway, a hurricane flood protection levee as well as several railway tracks.

Direct Pipe® has been chosen as the preferred installation method by the Design engineers Arceneaux Wilson & Cole and Geoengineers over HDD in order to comply with the very strict bore pressure tolerances by the U.S. Army Corps of Engineers guidelines for levee crossings. The bore pressure model designed by Geoengineers has shown that the required factor of safety of 2 against hydraulic fractures could not be maintained with the HDD method. Laney Directional Drilling, who have successfully constructed the Aquashicola Creek Crossing for Williams (Transco) a year earlier have been awarded the project.

The crossing distance of 1,068m and the geology asked for a 48" Direct Pipe® system with a powerful 750to Pipe Thruster to install the 48" steel casing pipe. The alignment included vertical and horizontal curves to avoid existing infrastructure along the path. The on board gyro navigation system guaranteed the installation exactly along the predetermined alignment. Several sensors monitored the hydraulic pressure during the installation and made sure that the safety against hydraulic fractures could be maintained. The limited works space at entry side allowed only pipe section length of h of 400ft to be strung out before installation. It took only 22 days to complete the 1,068m crossing after jobsite preparation and stringing of the pipeline in April 2014. This project laid the foundation for several levee crossing to come.

## PIPE EXPRESS®

Pipe Express® from Herrenknecht is a new, semi-trenchless near-surface pipeline installation method. In this method, a buggy with a trenching unit creates a narrow, approximately 40 centimeter wide trench on the surface. Below it in the soil a boring machine is mounted that digs the actual tunnel with diameters of up to 1.50 meters and installs the pipeline in one step. The excavated soil is brought to the surface by the trenching unit and backfilled in the trench again behind the machine. Laborious finishing work is not required.



Figure 12: Direct Pipe® setup at the Sabine Neches Waterway Crossing



**Figure 13: Pipe Express® in operation in Sweden**

The pushforce for both excavation unit and pipeline is provided by a Herrenknecht Pipe Thruster located in the launch pit. The modular design of the entire system allows easy transport and relocation, as well as high flexibility in changing project conditions. The compact system is remote-controlled from the operating vehicle and no trenches have to be dug. Up to 2,000 meter long pipelines with a diameter of 900 – 1,500 millimeters (36" - 60") can thus be laid quickly and cost-efficiently.

Reference Project Pipe Express®

Stockholm, Sweden

Herrenknecht's semi-trenchless method Pipe Express® has completed its third successful pipeline installation project in Sweden, South of Stockholm. Züblin Scandinavia AB installed a 48" water pipeline more than a kilometer in length within twelve days. Züblin Scandinavia AB made the most of this enormous budget and time advantage. It used Pipe Express® for the laying of a 1,036 meter long section of a 48-inch water pipeline near Huddinge, some 10 kilometers south of Stockholm. This is the longest pipeline section ever installed by the Pipe Express® technology. After drilling started on February 22, on March 5, 2015 already the destination had been reached. In the most productive 12-hour shift, 221 meters of pipeline disappeared into the ground; the average construction performance was 0.70 meters per minute. About 60 percent of the construction time was taken up just with welding and coating the up to 224 meter long steel pipe sections.

Using the open-cut method sheet piles and groundwater lowering would have been necessary due to the extremely soft clay soil conditions. Therefore, the Pipe Express® method was chosen to work under groundwater, with a water level just below the terrain's surface. Groundwater lowering was not required. Thus, compared to conventional open-cut construction, Pipe Express® has significantly less impact on the environment, while simultaneously minimizing costs.

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Berlin to share expert knowledge within the framework of the 11th Pipeline Technology Conference. We would like to introduce you to this event's key findings which we have condensed to a number of relevant statements from important personalities from all over the world.

Please let us know your thoughts on these matters. An industry lives not only due to its order situation but also through its ability to maintain and develop a substantial dialogue about future challenges and opportunities.

I am looking forward to hearing from you!

Yours,

A handwritten signature in black ink, appearing to be 'K. Ritter', written over a light background.

**Dr. Klaus Ritter**  
**Pipeline Technology Conference Chairman**  
**Pipeline Technology Journal Editor in Chief**  
**President of EITEP**





## Core Statements from ptc 2016



**Dr. Ali Majedi,**  
Iranian Ambassador in Berlin / former Iranian Vice Oil Minister,

*"There are immense natural gas reserves within Iran and they are of potential significance for long-term security of supply to Europe. Only Iran has the sufficient capacities to overcome these geostrategic hurdles with respect to Europe. According to the latest BP report, Iran has even been placed ahead of Russia in the list of countries with the largest reserves of natural gas, with 34 billion cubic meters".*



**Cliff Johnson,**  
President American Pipeline Research Council International (PRCI),

*"We know that pipelines are the safest way of transporting oil and gas over long distances. But our industry is not very good in telling our story. All of us are ambassadors for this industry and we should try to sharing our achievements not just in technical conferences like this but also in non-technical public discussions".*



**Asle Venas,**  
Global Director Pipelines at the technical service provider DNV GL,

*"Europe requires a large volume of natural gas in order to fulfill future energy demands. I believe that, that, as well as the 'Southern Gas Corridor', 'Nord Stream 2' gas from Norway and LNG sources is also going to be required".*



**Dr. Thomas Hübener,**  
Technical Director at Open Grid Europe (OGE)  
Vice President Gas at DVGW,

*"The current network development plan for Open Grid Europe set out for the next five to ten years will require investments amounting to 4.4 billion Euros".*





**Prof. Dr. Gerald Linke,**  
Chairman of the DVGW

*"Natural gas harbors great potential for a future energy mix in Europe. According to his theory, LNG engines could be put to use in ships and trucks for heavy and mass transport and significantly reduce damage to the environment. 'Power to gas' is another significant incentive for the energy mix and environment conservation that should not be underestimated".*



**Dr. Klaus Ritter,**  
Chairman of the ptc / President of EITEP Institute

*"We saw that technology and service providers from the 'old' pipeline countries in North America and Western Europe, where valuable regulations and lessons learned in the transport of oil, gas and water have been in place for years, were in Berlin meeting operators predominantly from the 'new' pipeline countries in Latin America, Eastern Europe, Asia and Africa. These kind of encounters lead to valuable international technological exchanges".*



**Michael Beller,**  
Global Strategy Manager at ROSEN

*"We must gear up for the upcoming challenges: As part of an international forum held by ROSEN, it was made clear that in the face of rapidly growing complexity, ideas from other industry sectors and subject areas such as 'big data' and 'data mining' are also gaining in significance".*

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