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IS A NATURAL GAS BOOM COMING?

Dr. Klaus Ritter
Editor in Chief

The International Pipeline Technology Conference,on May 2 – 4 in Berlin, is ready

It is clear these days that all countries with an abundance of natural gas reserves are pushing into the European market. High investments are being made for the construction of pipelines and LNG plants.

- Russia will pump up to 86.5 billion cubic meters annually to Europe via two new pipelines (Nord Stream 2 and TurkStream), starting in 2020.
- After an initial period of expansion, ten billion cubic meters will be pumped into Europe via the Southern Gas Corridor as well.
- In addition, higher deliveries of LNG from North Africa, Norway/Scotland, and the Middle East and North America (surpluses from fracking) are under discussion.

The investment required is immense - but obviously will not be spared, because additional needs will arise — such as system-relevant gas-fired power plants, which are necessary to ensure the stability of the electricity networks during further expansion to incorporate renewable energy. Lower rates of production within Europe, the upcoming L-H gas conversion, and the circumvention of the Ukraine cannot alone explain this development.

In the meantime, the transport networks in Europe are consolidated - German transmission system operators alone are investing over €4 billion according to grid development plans for the period 2016-2026.

Heinz Watzka
Senior Advisor

The best available material and equipment has to be used in the construction processes — as well as the operation and maintenance — of these new installations and existing pipelines, and they will have to be operated economically and reliably for many years to come because of the high levels of investment involved. This means seeking an exchange of experience at a high international level in these international projects, in order to meet this need.

The "Pipeline Technology Conference" (ptc) and accompanying exhibition have been providing top-level exchange experience for 12 years. This is the largest relevant event in Europe. This year's event will take place from May 2 – 4 in Berlin. It will include immersive seminars and a scientific poster show, at which 12 research institutes will present their works.

600 participants from more than 50 countries are expected to attend. They will have access to 20 innovative sessions, 80 innovative lectures, and two discussion sessions with 10 policy-makers providing an overview of the state of pipeline science and technology. Session 1.1 was compiled by the DVGW. In the accompanying exhibition, 60 leading pipeline companies from all over the world will be on hand for in-depth discussions.

The event provides a comprehensive discussion platform for representatives from the oil, gas, water, and product pipeline industries. It will cover technical topics regarding onshore and offshore issues, materials, planning, construction, automation, and integrity management. An IPLOCA (International Pipeline & Offshore Contractors Association) regional meeting and a BIL (Federal Information System for Line Research) informational event will also be included in this year's PTC.

A 42-member Advisory Committee, which includes members from 13 nations, provides support for this comprehensive program. The committee, previously led by Dr. Klaus Ritter of the EITEP Institute together with Mr. Uwe Ringel of ONTRAS, will now be led by Mr. Heinz Watzka, former Managing Director of Open Grid Europe and Mr. Dirk Strack, Technical Director TAL - Transalpine Pipeline.

A worthwhile endeavor.

We are working constantly to uphold the continuous 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.

- eitep@eitep.de
- www.pipeline-journal.net
- www.pipeline-conference.com

Yours,

Dr. Klaus Ritter.

President, EITEP Institute

Heinz Watzka

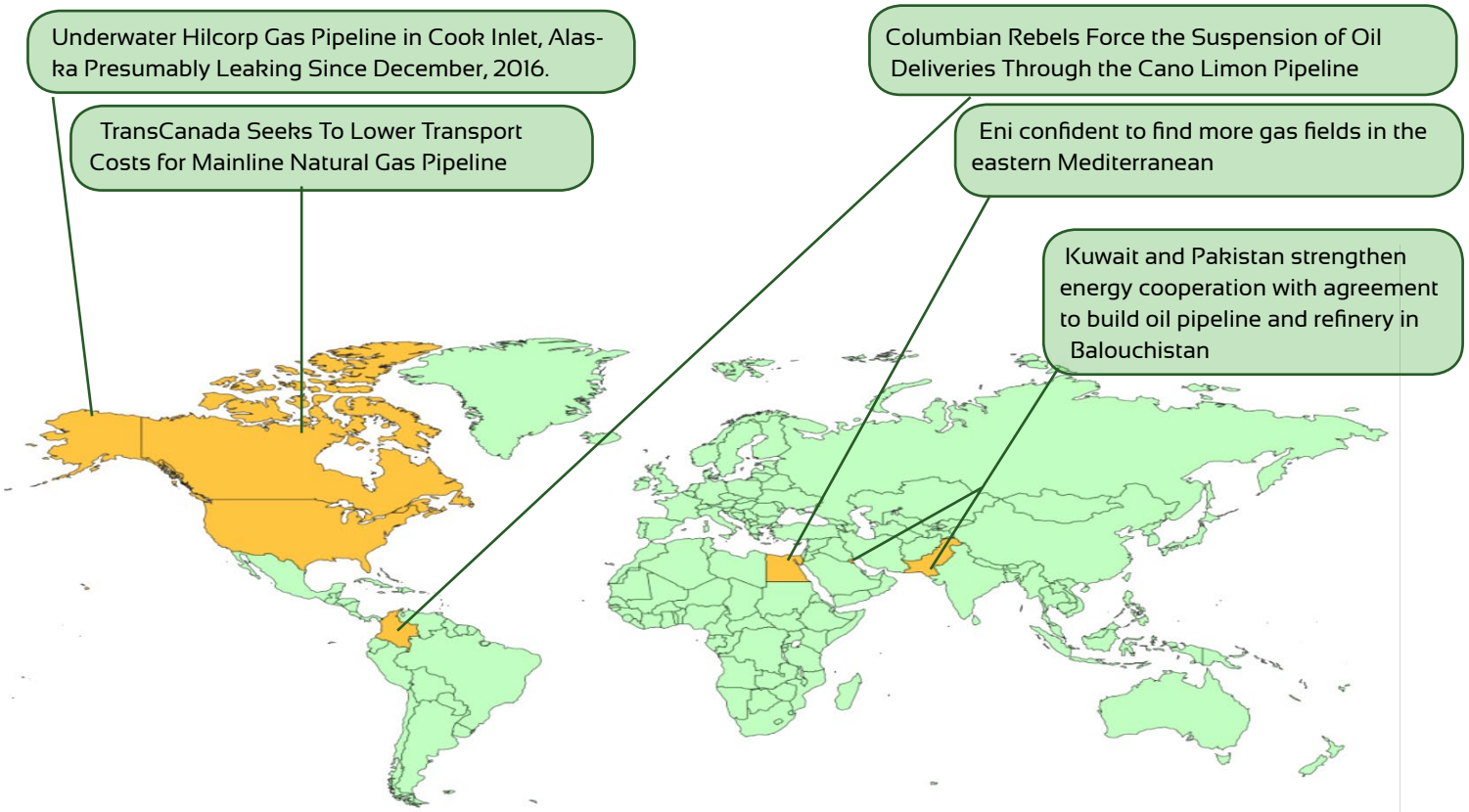
Senior Advisor, EITEP Institute

THIS ISSUE'S COMPLETE CONTENT

MARCH 2017
ISSUE 2

THIS ISSUE: OPERATIONS

WORLD NEWS



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The Importance of Combatting Corrosion

Andreas Pfanger >>>>>>>>>> NDT Global GmbH & Co. KG

Figure 1: High-resolution ultrasonic in-line inspection by NDT Global

ABSTRACT

No matter the location of a pipeline – be it under or above ground, offshore or onshore – without the necessary protection or maintenance, it is vulnerable to corrosion. The structural integrity of a pipeline is severely susceptible to damage.

As pipeline materials are often placed in environments where corrosion is a regular occurrence, the need to manage and mitigate the potential damage caused by corrosion is paramount. These environments – sometimes referred to as extreme – push the pipeline materials beyond their considered design and construction. Even in occasions where manufacturers account for corrosion, the volatile nature of the environment often results in unanticipated corrosion damage.

It is important, therefore, to record high-resolution data with the latest and most innovative tool technology to help manage the threat that corrosion poses. NDT Global employs such tactics. A leading supplier of ultrasonic pipeline in-line inspection (ILI) and data analysis, the company has conducted ultrasonic testing (UT) on countless pipelines and has a combined 465 man-years of experience in data analysis.

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THE DANGER OF UNCHECKED PIPELINE CORROSION

So why is corrosion potentially so destructive towards a pipeline? Predominantly, it influences a pipe wall's surfaces both internally and externally. When the medium transported in the pipe – such as crude oil – has traces of water or bacteria, it can initiate internal corrosion. This can grow rapidly in a pipeline. In instances where external coatings suffer from corrosion, it is often a result of environmental factors and coating damage.

When looking at previous cases and reportage of pipeline failures, pipeline inspection activity in the North American region over recent years underlines the importance of monitoring corrosion in pipelines.

The Canadian Energy Pipeline Association (CEPA) found that between 2010 and 2014, metal loss was the leading cause of pipeline failure amongst its members. CEPA members attributed 34 per cent of their failures to metal loss, which is more often than not a result of corrosion – be it internal or external. The fact that ultrasonic ILI detects and forecasts both internal and external corrosion underlines the importance and pertinence of the service to the pipeline management industry.

Moving slightly south but maintaining a similar theme, from the 1970s to 2000, the US Department of Interior Mineral Management Service concluded that the leading cause of leaks in offshore pipelines was internal corrosion, attributing 35 per cent of cases to it. While natural causes were the next highest, they trailed significantly behind.

The operation of an ultrasonic ILI is particularly pertinent to pipeline management, as it is a proactive means of understanding and combating the threat and uncertainty of corrosion.

This uncertainty is an underlining attribute as to what makes ILIs so critical. As NDT Global affords itself the ability to compare the multiple datasets, by performing multiple inspections. This enables its team to estimate corrosion growth rates and calculate a safe operating pressure. In turn, pipeline operators make more informed and decisive decisions when it comes to maintenance because of this information.

The measurement of safe pressure levels is incredible imperative in relation to offshore pipelines. Understanding the correct times to reduce pressure levels not only helps to prevent ruptures, it also helps to indicate a line's lifespan.

COMBATING CORROSION WITH CUTTING EDGE TECHNOLOGY

As corrosion has traditionally been, and continues to be, a very real threat to pipeline integrity management services, NDT Global launched a high-resolution metal loss inspection service in 2015 to help combat its threat. In 2015, using its new Evo Series 1.0 UMp tool, the ultrasonic in-line inspection company was able to release a new technology to the market that reliably detects defects as small as 5 mm (0.2"). This accuracy represent a two-fold improvement in the minimum sizing threshold from previous, entry-level ultrasonic services – which could detect 10 mm (0.4") defects.

Figure 2: Special tool configuration by NDT Global's ILI experts

The ultrasonic sensors on the tool, which cover the full 360-degree range of the pipeline, emit a short pulse of ultrasonic energy. The internal wall reflects this ultrasonic energy. As well as this, the rear wall reflects a portion of the signal that enters the pipe wall. Using the speed of sound for the medium and steel, the distance from the sensor to the inner wall (Stand-Off, i.e. SO) and the wall thickness (WT) can be calculated.

The Evo Series 1.0 has the capability to operate up to four times faster than older generation tools and simultaneously uses a higher resolution. As the throughput reduction is not at the same level as with standard tools, operators can benefit from cost savings. Identifying the contours of a defect is now more reliable as higher resolution allows for more measured values per metal loss anomaly. This identification is integral to for meaningful corrosion growth analysis and integrity assessments.

While there are myriad enhancements of measuring and forecasting corrosion with thanks to higher resolution, there are, inevitably, challenges it poses. Growth rates are deter-

"Even in occasions where manufacturers account for corrosion, the volatile nature of the environment often results in unanticipated corrosion damage."
Andreas Pfanger

mined by comparing datasets from two or more inspections. The introduction of the latest generation tool came in 2015, so engineers compare data sets with results from older and less accurate tools as a result. Some uncertainty surrounding whether an anomaly has grown rapidly, or simply wasn't detected on previous scans may occur. Engineers analyze the number of sensors measuring possible corrosion growth to determine the difference. They conclude that if only one or two sensors were to detect the deepest part of the anomaly, it is likely that the older technology missed it altogether. In summary, the more sensors that pick up this deepest section, the more likely it is the growth occurred, rather than a technical miss.

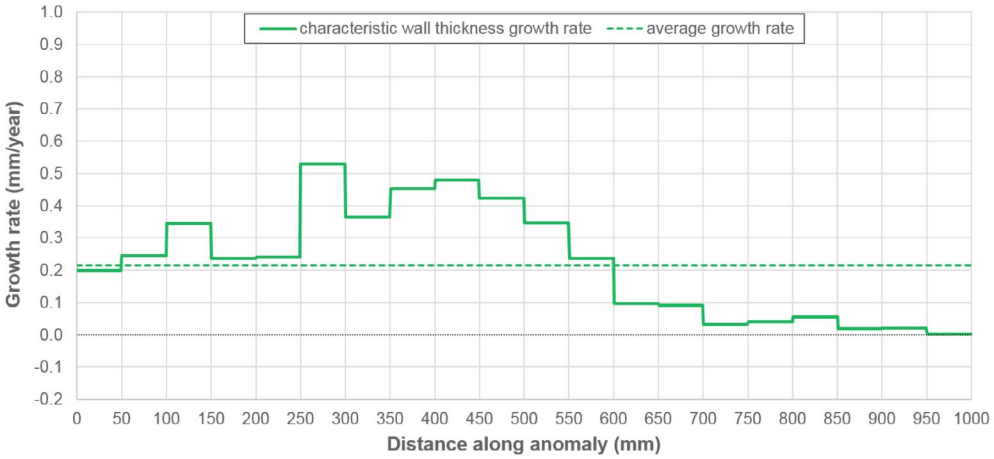

Figure 4: Corrosion growth rates

EXTERNAL CORROSION IN HIGH-RESOLUTION

This is a look at an instance where NDT Global worked with a pipeline operator that had an issue with external corrosion on a riser section that was approximately 185 m (607 ft) in length. Another company had previously inspected this line in 2014.

Conducted in 2016, the ILI results showed the most significant external anomaly was found in the splash zone, and had a depth of 8.0 mm (0.31 in), leaving a remaining wall thickness of 7.0 mm (0.28 in). It spans length of 1.0 m (39 in) and covers the full circumference of the pipe. This heavy corrosion shows a damaged coating, allowing seawater to penetrate to the metal. Here, the client needed a detailed growth assessment considering the high-resolution depth profile of this external corrosion.

The division of the anomaly into eight 45-degree boxes allowed the inspectors a more detailed look at it. Figure 3 shows the comparison of river-bottom and resulting characteristic wall thickness profiles from one of these boxes. Figure 4 shows the growth rates.

In an intriguing discovery, the corrosion rate varied significantly along the length of the anomaly. The first 600 mm (24") of the 1000 mm (39") area featured corrosion that grew roughly twice as fast as the spots in the latter half. In this first section, the rate ranged from 0.5 mm (0.02")/year to 0.6 mm (0.024")/year, depending on the circumferential position.

"In 2015, using its new Evo Series 1.0 UMp tool, the ultrasonic in-line inspection company was able to release a new technology to the market that reliably detects defects as small as 5 mm (0.2")."

Andreas Pfanger

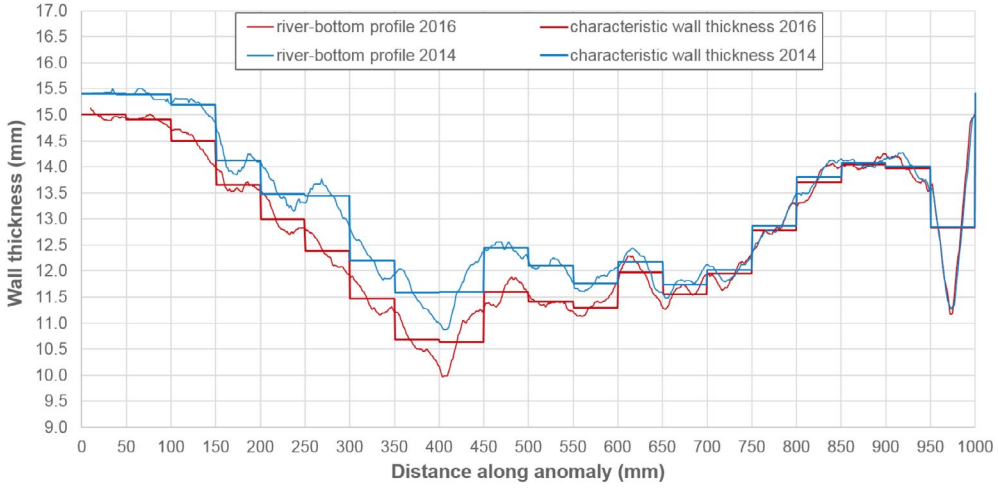

Figure 3: A comparison of river bottom and wall thickness profiles

However, after 600 mm (24") the anomaly was growing at a maximum rate of 0.2 mm (0.01")/year, and several of the regions showed no growth at all. These high-level growth results serve as input for advanced predictions of 3D finite element pressure and remaining pipeline life. As dirt and debris can also aggravate internalcorrosion, regular cleaning of pipelines and the injection of corrosion inhibitors are important strategies for slowing or preventing internal corrosion. Coatings and cathodic protection prevent external corrosion.

FROM OUT TO IN - EXTERNAL TO INTERNAL CORROSION

While external corrosion was the focus of the previous case study, this one examines a project where internal corrosion as an issue. NDT Global completed the first ultrasonic ILI of an offshore crude oil pipeline in early 2015.

After this inspection, data analysis teams discovered that this five-year-old line had unexpectedly significant internal corrosion, given its age. Pitting and extensive channeling corrosion with depths up to 10 mm (0.4", 60 per cent of the nominal wall thickness) were found mainly on the bottom of the pipe, but also along the sides to the mid-point.

Based on the discovery of advanced corrosion, the client expected to see corrosion growth between 2 mm and 2.5 mm (0.08" and 0.10") per year. They believed the significant corrosion growth was due to the crude oil's temperature, which was between 60 and 70 degrees Celsius, and insufficient cleaning of the pipeline during the first few years of its operation. In an attempt to slow further damage, the procedures for cleaning and injecting of corrosion inhibitors were changed.

One year after the initial ILI, the client decided to re-inspect the pipeline in order to prove the effectiveness of the measures taken. Having two high-resolution ILI data sets enabled a detailed corrosion growth assessment based on data. Because of this, the inspection team compared corrosion anomalies' river-bottom profiles, instead of the peak depths only. For the majority of the anomalies, the assessment revealed that corrosion growth occurred between 2015 and 2016.

Based on our 2015/2016 comparison, the integrity team found the maximum growth rate was approximately 1.2 mm (0.05 in) per year, which was not as fast as the clients expected based on the first inspection.

As it was an offshore pipeline, one of the most critical pieces of information to determine was the safe operating pressure. Repairing offshore pipelines is very expensive, so extrapolating the condition to know how long you will be able to operate the pipeline at certain pressure levels, or when you have to reduce pressure is necessary. Operation of offshore pipelines strongly relies on the output of these corrosion growth predictions and assessments.

"For pipeline operators to plan their pipeline integrity management services intelligently, it is imperative that they have accurate data outlining the presence of internal and external corrosion."
Andreas Pfanger

The calculation of the safe operating pressure was in accordance with Recommended Practice DNV-RP-F101, which makes use of the detailed river-bottom profiles of the corrosion features.

The calculated safe operating pressure of the pipeline dropped by 11 bar (160 psi) between 2015 and 2016, but remained above the maximum allowable operating pressure (MAOP) of 140 bar (2030 psi).

NDT Global calculated forecasts of the pipeline's future safe operating pressure based on different corrosion growth scenarios. Taking account for the most conservative scenario, where corrosion growth of all anomalies continues at the maximum rate of 1.2 mm (0.05 in) per year determined from the 2015/2016 comparison, the remaining life of the pipeline at the established MAOP is eight years (Figure 1).

After comparison and assessment, the 2015 and 2016 ILI results showed that the initial prevention measures slowed the corrosion growth after the 2015 ILI. In order to reduce the still high growth rate, the client plans to optimize the cleaning and corrosion inhibition procedures. Therefore, a plan is in place for a re-inspection and updated integrity assessment in order to prove the success of these strategies.

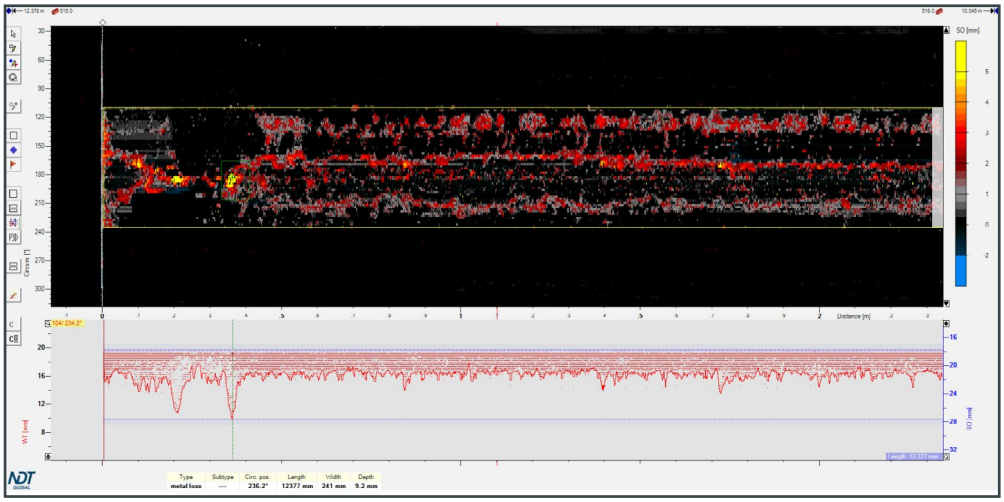

Figure 5: Inspection data of internal channeling corrosion

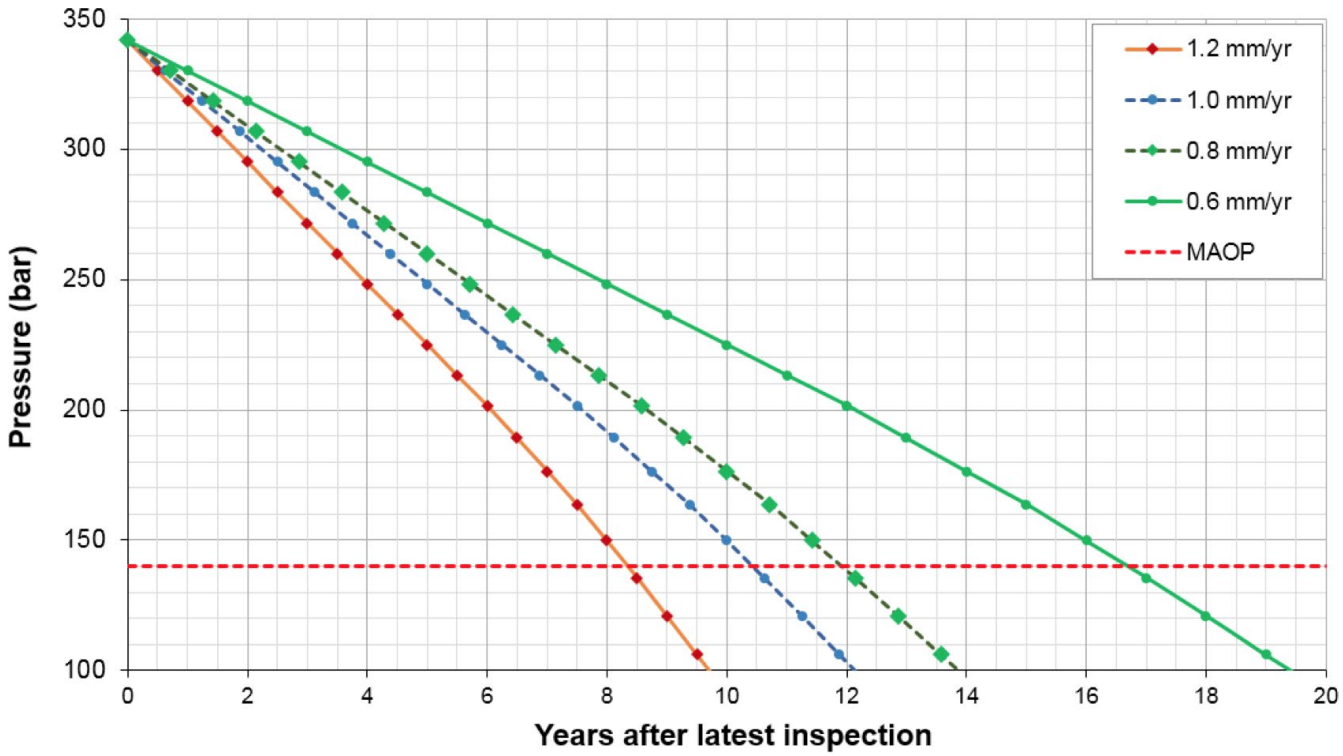

Figure 6: Remaining life of the pipeline at established MAOP

UNCHECKED CORROSION HAS CONSEQUENCES

As outlined above, regularly monitoring accurate data to help understand the rates of corrosion plays a crucial role the lifespan of a pipeline. With this in mind, NDT Global uses cutting-edge technology, providing high-resolution information about the internal and external condition of pipelines.

For pipeline operators to plan their pipeline integrity management services intelligently, it is imperative that they have accurate data outlining the presence of internal and external corrosion. This can also offer a good indication of a pipeline's lifespan, simultaneously aiding long-term planning and safety in pipeline management.

For more information about NDT Global and its inspection services, go to
www.ndt-global.com

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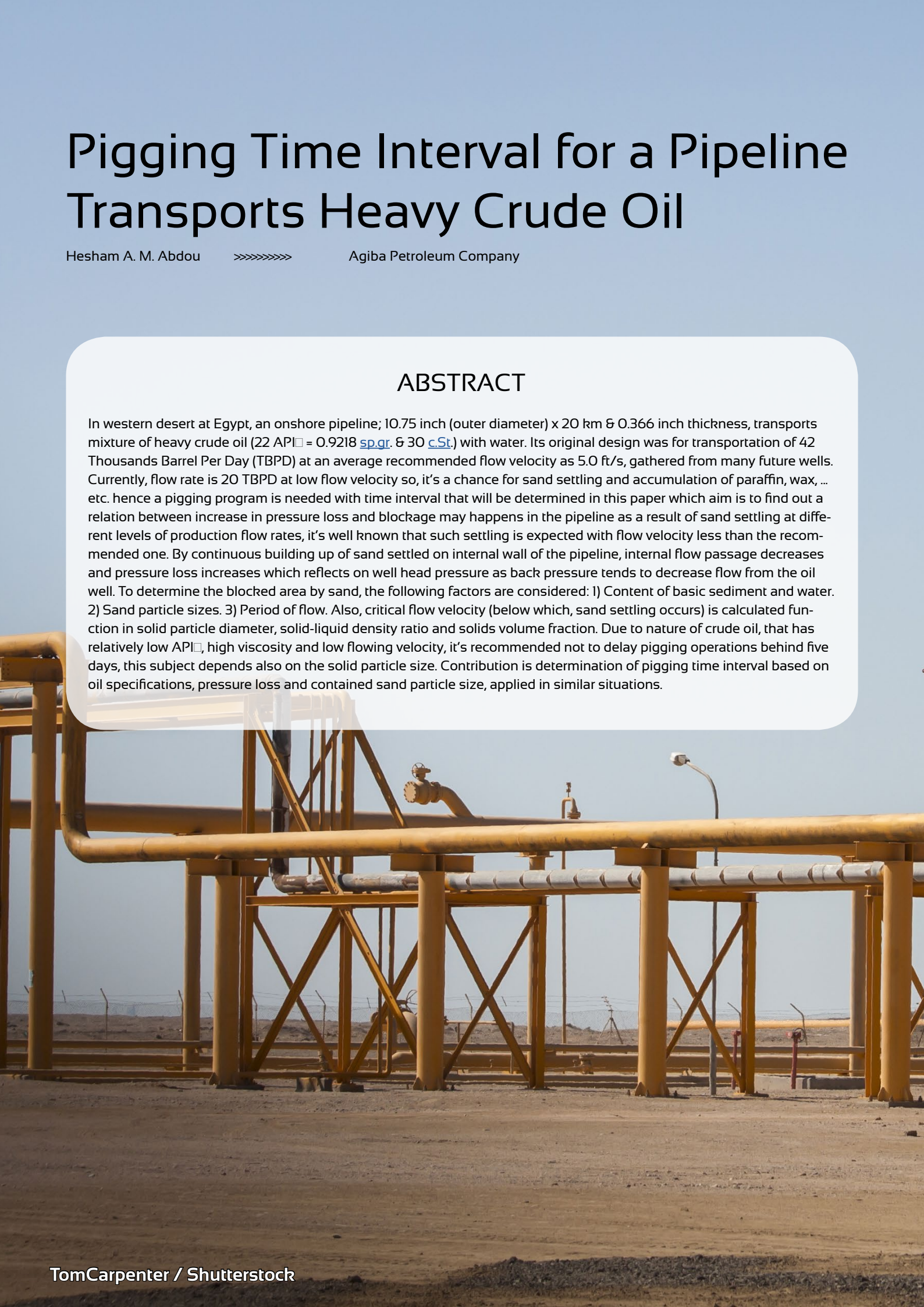
Pigging Time Interval for a Pipeline Transports Heavy Crude Oil

Hesham A. M. Abdou >>>>>>>>>> Agiba Petroleum Company

ABSTRACT

In western desert at Egypt, an onshore pipeline; 10.75 inch (outer diameter) x 20 km & 0.366 inch thickness, transports mixture of heavy crude oil (22 API□ = 0.9218 sp.gr. & 30 c.St.) with water. Its original design was for transportation of 42 Thousands Barrel Per Day (TBPD) at an average recommended flow velocity as 5.0 ft/s, gathered from many future wells. Currently, flow rate is 20 TBPD at low flow velocity so, it's a chance for sand settling and accumulation of paraffin, wax, ... etc. hence a pigging program is needed with time interval that will be determined in this paper which aim is to find out a relation between increase in pressure loss and blockage may happens in the pipeline as a result of sand settling at different levels of production flow rates, it's well known that such settling is expected with flow velocity less than the recommended one. By continuous building up of sand settled on internal wall of the pipeline, internal flow passage decreases and pressure loss increases which reflects on well head pressure as back pressure tends to decrease flow from the oil well. To determine the blocked area by sand, the following factors are considered: 1) Content of basic sediment and water. 2) Sand particle sizes. 3) Period of flow. Also, critical flow velocity (below which, sand settling occurs) is calculated function in solid particle diameter, solid-liquid density ratio and solids volume fraction. Due to nature of crude oil, that has relatively low API□, high viscosity and low flowing velocity, it's recommended not to delay pigging operations behind five days, this subject depends also on the solid particle size. Contribution is determination of pigging time interval based on oil specifications, pressure loss and contained sand particle size, applied in similar situations.



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INTRODUCTION

As per pipeline design as 10.75" O.D. and thickness as 9.3 mm for 11 km & 14.3 mm for 0.5 km, flowing velocity through the pipeline found low, compared with the recommended velocity through pipelines as (4-5) ft/s. So, it will be a chance for sand settling and accumulation of paraffin, wax, .. etc. hence there will be a need for a pigging program with time intervals that will be determined in this study. Also, there is an expected problem regarding pig passing from the smaller internal diameter to the bigger one.

DISCUSSION

Aim of this study is to find out a relation between increase in pressure loss and blockage may happens in the pipeline as a result of sand settling at different levels of production flow rates, it's well known that such settling is expected with flow velocity, less than the recommended velocity at all figures up to 20,000 bbl/d. Flowing velocity through the pipeline is determined by the next Eq., plotted in Fig.1:

$V = 11.915\ Q / D^2$

Where:

V: flowing velocity, ft/s
Q: flow rate, 1000 bbl/d
D: pipeline inside diameter, in.

CALCULATION PRINCIPLES

- Total pipeline volume, V (bbls) = $3.187\ L\ [D_1^2 + D_2^2]$
- $D_1 = 9.624$", $L_1 = 0.5$ km & $D_2 = 10.018$", $L_2 = 11.0$ km & $L = L_1 + L_2$
- BS %, is taken into considerations as 0.5 & 1.0 % by volume.
- Different sand particle sizes are taken as 100, 200, 300, ... etc. up to 800 micron meter.
- Settled sand volume, S = Q x BS %
- Sand blockage %, B = 100 x n x S/V ... n: number of days
- Free volume for flow pass, (FV) bbls = V (1- 0.01 B)
- Free pipeline area for flow pass, (FA) $ft^2 = 17.114 \times 10^{-4}$ "FV" / L
- Equivalent Inside Diameter for sand blocked area (EID) = $13.541\ (FA)^{0.5}$

After getting (EID), pressure loss is calculated as per next article:

PIPELINE HYDRAULICS

CALCULATION OF GAS TO LIQUID RATIO, R

From given data: Gas to Water Ratio, GWR = 202.3 scf/bbl

Gas to Oil Ratio, GOR = 65.44 scf/bbl

As: R = gas / (oil + water)

(1/R) = (oil/gas) + (water/gas)

(1/R) = (1/65.44) + (1/202.3)

R = 49.45 scf/bbl

MIXTURE DENSITY CALCULATED AS:

$\rho m = [(12{,}409 \times S.G. \times P) + (2.7 \times SRP)] / [(198.7 \times P) + ZRT]$ [1]

Where:

ρm = mixture density, lbm/ft^3 = unknown (?)

P = operating pressure = 270 psia

R = 49.45 scf/bbl

S.G. = composite specific gravity of oil and water = 0.9985

T = operating temperature, °R = (150° F) +460 = 610

S = gas specific gravity at standard conditions = 0.8027

Z = gas compressibility factor = 0.94

So, $\rho m = 41.1\ lbm/ft^3$

CALCULATION OF REYNOLDS NUMBER, RE [2]

$Re = 1.4777\ \rho m\ Q / (\mu\ D)$

Where:

ρm: lbm/ft^3 .... Q: bbl/d .... μ: c.P. .... D: in.

CALCULATION OF HYDRAULIC FRICTION LOSS, H_F [2]

$H_f = 6.028 \times 10^{-4}\ \rho m\ f\ L\ Q^2 / D^5$

Where:

H_f: hydraulic friction loss, psi

ρm: mixture density, lbm/ft^3

f: friction loss factor is determined as: f = 64 / Re .... laminar flow .. or

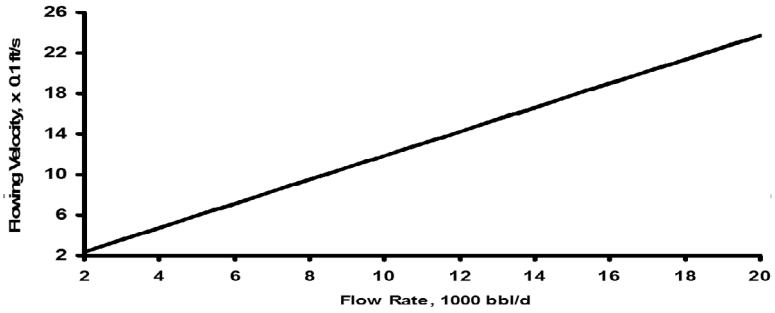

Figure 1: Flow Rate versus Flowing Velocity Through the Pipeline

$f = 1.325 / [\ln \{(\varepsilon/3.7/D) + 5.74\ Re^{-0.9}\}]^2$ [3]

ε: pipe roughness .... L: km .... Q: bbl/d ..... D: inside pipe diameter, in.

Present work will start from this point, following are data of the flowing media:

- Oil API = 22.1 (SG = 0.9212)
- Water S.G. as per lab analysis report = 1.11
- Gas S.G. as per analysis report = 0.8027

Year	year of prod.	gross, bbl/d	Water Cut, %	Oil Cut, %	composite sp.gr.
2009	0	2000	10	90	0.9401
		4000	10	90	0.9401
		6000	10	90	0.9401
		8000	10	90	0.9401
2010	1	10000	10	90	0.9401
		12000	15	85	0.9495
		14000	15	85	0.9495
		16000	15	85	0.9495
		18000	15	85	0.9495
2011	2	20000	15	85	0.9495
		19000	20	80	0.95896
		18000	20	80	0.95896
		17000	20	80	0.95896
2012	3	16000	20	80	0.95896
2013	4	15000	25	75	0.9684
2014	5	14000	30	70	0.9778
2015	6	13000	35	65	0.9873
2016	7	12000	40	60	0.9967
2017	8	11000	45	55	1.0062
2018	9	10000	50	50	1.0156
2019	10	9000	55	45	1.02504
2020	11	8000	60	40	1.03448
2021	12	6000	65	35	1.04392
2022	13	7000	65	35	1.04392
2023	14	8000	70	30	1.05336
2024	15	9000	75	25	1.0628
2025	16	8000	80	20	1.07224
2026	17	7000	85	15	1.08168
2027	18	6000	90	10	1.09112
2028	19	5000	95	5	1.10056
2029	20	4000	100	0	1.11

SETTLING VELOCITY, V_S (m/s)

$V_s = g (\rho p - \rho) Dp2 / (18 \mu)$

Where:

ρp & ρ: densities of solid particle and liquid respectively, kgm/m^3.

D_p: diameter of solid particle, micron meter.

μ: continuous media viscosity, Pa.s = 1000 c.P.

CRITICAL VELOCITY, V_C IS CALCULATED AS PER OROSKAR & TURIAN [4]

$V_c = 1.85 [g d (S-1)]^{0.5} C^{0.1536} (1-C)^{0.3564} (d/D)^{-0.378} Re^{0.09} X^{0.3}$

Where:

d = solid particle diameter, m

g = earth gravitational, 9.81 m/s^2

S = ratio of solid to liquid density

C = solids volume fraction

$Re = \rho_m V_s d / \mu$

X = fraction of eddies with velocities exceeding the hindered settling velocity of the particles, taken as 0.75

Particle Size, micron meter	Critical Flow Rate, bbl/d
100	8,133
200	10,672
300	12,511
400	14,004
500	15,284
600	16,417
700	17,439
800	18,376

Table 1: Sand particle Size Versus Critical Flow Rate

This means for example that with sand particle size 200 & 600 micron meter, flow rates up to 10,672 bbl/d & 16,417 respectively will settle sand. In figures 2 & 3 here-in under, plots for critical flow rates versus pipeline pressure loss.

For example, pressure loss with no pigging when sand size is 600 micron will be 76 & 100 psi with BS = 0.5 & 1% respectively. It's suitable to say that the calculations can be run for different BS % to get Corresponding pressure loss in every case.

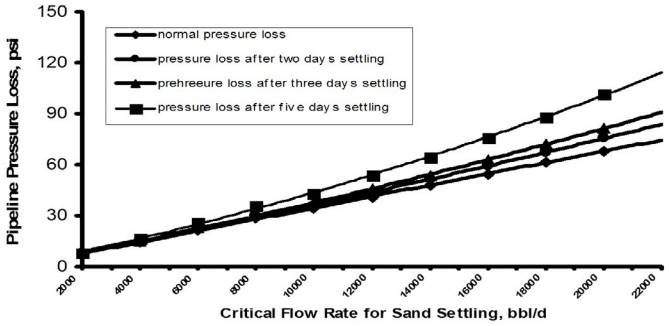

Figure 2: Critical Flow Rate Versus Pipeline Presure Loss, Case 0.5 % BS

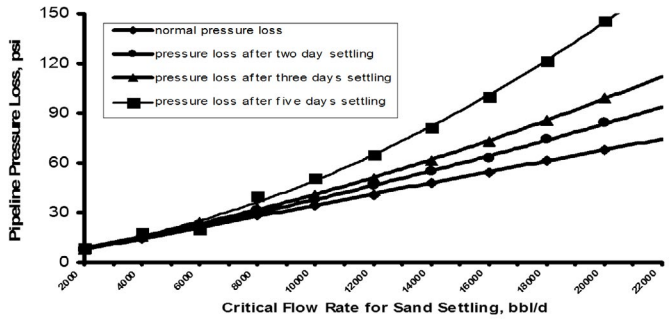

Figure 3: Critical Flow Rate Versus Pipeline Pressure Loss, Case 1.0% BS

2.5 CONCLUSION

Due to nature of project crude oil, has relatively low API, high viscosity and low flowing velocity, it's recommended not to delay pigging operations behind five days, this subject depends also on the solid particle size.

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[3] PIPE-FLO Stock User's Manual & Method of Solution, Eq.15, p.19
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Wireless Portable LDS for Theft Detection

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Abstract

Oil pipeline Leak Detection System (LDS) is widely used to minimize the environmental damages and financial losses by discovering the leakage in its early stages. However, due to the long distance between sensors and immobility, existing wired stationary LDS has inherent limits in detection accuracy.

We present a wireless portable LDS which can find the leakage location more accurately than conventional LDS. This wireless portable LDS can transmit and receive pressure transient data in the pipeline via Long Term Evolution (LTE) high speed wireless communication in real time. It is possible to operate more than 24 hours with equipped battery and also to be connected with power supply for continuous monitoring.

Mobility of the wireless portable LDS allows us to narrow the suspected range of the leakage event step by step and to minimize the detection error. Wireless portable LDS can be used either by itself or combined with existing LDS to improve the sensitivity.

This wireless portable LDS will be helpful to locate very small leaks as well as intermittent theft for the pipeline protection.

INTRODUCTION

Most of the global pipeline companies have adopted and operated various LDS to prevent environmental and economic damages caused by oil leaks. Generally, LDS is used to notify leak occurrence and expected leak point to system supervisor and it is classified with non-continuous type and continuous type. The continuous type is divided into internal type and external type [1]. Since various types of LDS have their own advantages and disadvantages, it is evitable to consider a variety of aspects such as pipeline characteristics and surrounding environment to select suitable LDS satisfying user's needs.

This article is focusing on an internal type LDS for long distance underground pipelines for petroleum products.

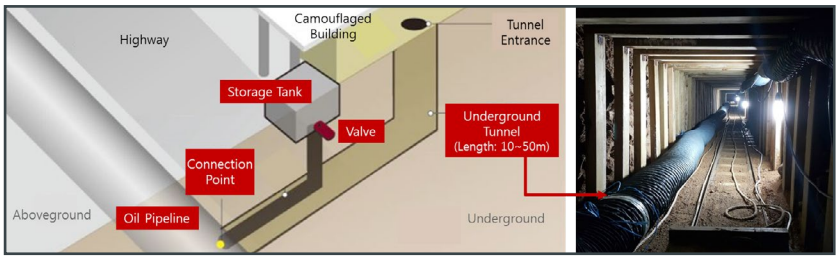

Figure 1: Long distance theft schematic diagram and underground tunnel [2]

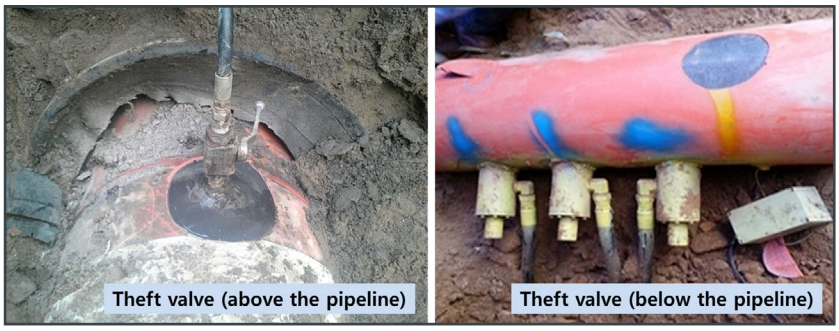

Figure 2: Small size hoses(½ inch) connected with oil pipeline for theft [3]

KOREA'S OIL PIPELINE ENVIRONMENT AND THEFT STATUS

OIL PIPELINE ENVIRONMENT IN KOREA

Daehan Oil Pipeline Corporation (DOPCO) is Korea's only pipeline company specializes in transportation of refined petroleum products. It has total 1,200 km of pipelines throughout the country and most of the pipelines are buried under the ground. DOPCO's pipeline is multi-product pipeline. The pipelines pass through various places such as mountainous terrain, highway, river, seabed and downtown.

Because most of the pipelines are distributed in highly populated areas, it is useful to patrol along the pipeline to minimize the oil leak accidents caused by third party interferences (TPI). Therefore, our main target is the detection of theft who is attempting to steal far from the pipeline.

OIL PIPELINE THEFT STATUS IN KOREA

A notable feature of pipeline thefts in Korea is that it is an enterprise type with professionalism. Excavation is inevitable to steal from underground pipeline. In the past, they used to dig right above or in the vicinity of the pipeline, but nowadays they are attempting to build underground tunnel and camouflaged workshop with buildings at a location far from the pipeline as shown in Figure 1. Hence, detecting the theft has been relatively difficult using visual or probing equipment.

Another feature is that it uses a small diameter hose, and tries to use a low flowrate with over a long period of time as shown in Figure 2. In this case, devices with more accurate sensors are needed to distinguish the minute changes in the pipe due to the leakage caused by external factors.

In addition, as shown in Figure 3, valves, manifolds and professional measuring equipment such as density meters, temperature gauges, pressure gauges are used in professional thefts. Thieves confirm the operation information including oil type and pipeline operating conditions by using the equipment, so that they can steal the desired product when DOPCO's monitoring is slack.

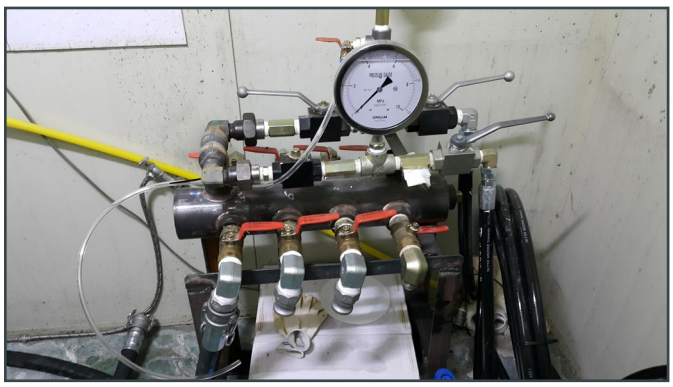

Figure 3: Measuring equipment for oil pipeline theft

DEVELOPMENT BACKGROUND OF DOPCO'S WIRELESS PORTABLE LDS

DOPCO employs pressure point analysis method with precise pressure sensors which can detect small leaks and monitor pipeline leaks continuously. DOPCO's LDS is in-

stalled over the whole pipeline, and continuously upgraded. The basic theory of pressure point analysis method is detecting the pressure difference between before and after a leak occurs at single point along the pipeline [4]. Therefore, by comparing the measured pressure difference data between two points which are located at both ends of a section, DOPCO's LDS can detect the leak and localize the spot as shown in Figure 4.

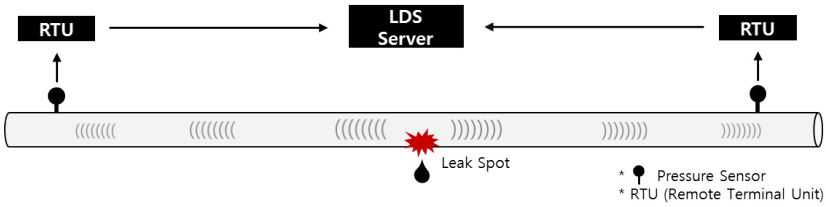

Figure 4: Schematic diagram of pressure point analysis LDS

The pressure sensors should be installed as close as possible to each other to increase the accuracy of the LDS. However, it requires high installation costs. To overcome this limitation, we considered mobile LDS, where users can install and uninstall them wherever we want.

In this paper, we introduce MD-POLISTM (Mobile DOPCO Pipeline Oil Leak Inspection System) technology in accordance with the environment of the Korea followed by the system configuration and result of performance test.

In addition, to build the system which can be operated wherever the users want, wireless data transmission technologies such as satellite, cellular or radio communications have been examined [5]. Among these technologies, DOPCO adopted LTE communication network with high transmission velocity (1000 data/s), widespread coverage as shown in Figure 5.

DOPCO WIRELESS PORTABLE LDS, MD-POLIS™

MD-POLIS™ is patented mobile leak monitoring system combined with LTE communication, Global Positioning System (GPS) sensor and ultra-precise pressure sensor [7]. It can be coupled with stationary LDS, D-POLIS™, for tracking and narrowing the leak suspected range.

MD-POLIS(tm) is patented mobile leak monitoring system combined with LTE communication, GPS sensor and ultra-precise pressure sensor.

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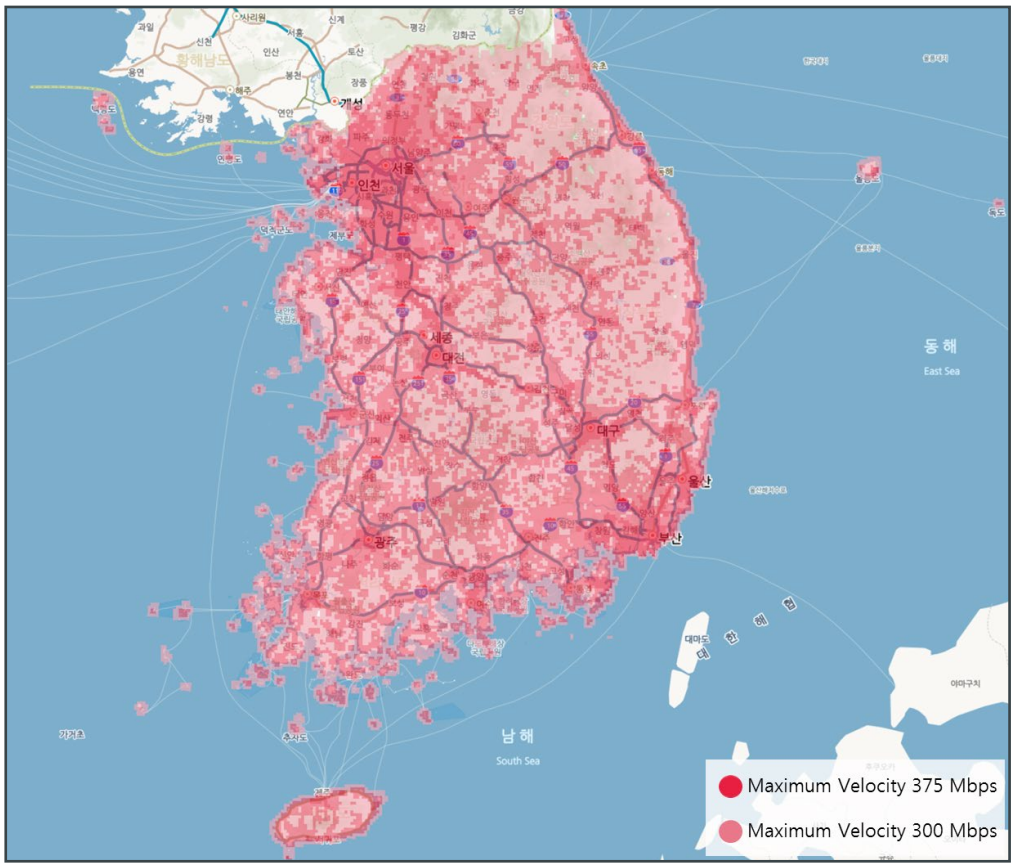

Figure 5: LTE coverage map in Korea (SK Telecom) [6]

OPERATION CONCEPT OF MD-POLIS™

MD-POLIS™ detects the leakage through data in pressure changes, transmitted from the measurement part (pressure sensor at both ends) as shown in Figure 6.

In case of leak, the pressure drop from the leakage point is transmitted to the two measuring points and appears on the client screen. At this time, MD-POLIS™ perceives inflection points of pressure trends and finds start point, end points and flowrate change points of the leak as shown in Figure 6.

Before generating the leak occurrence alarm, MD-POLIS™ filters the pressure noise due to the operation of facility such as valves and pumps.

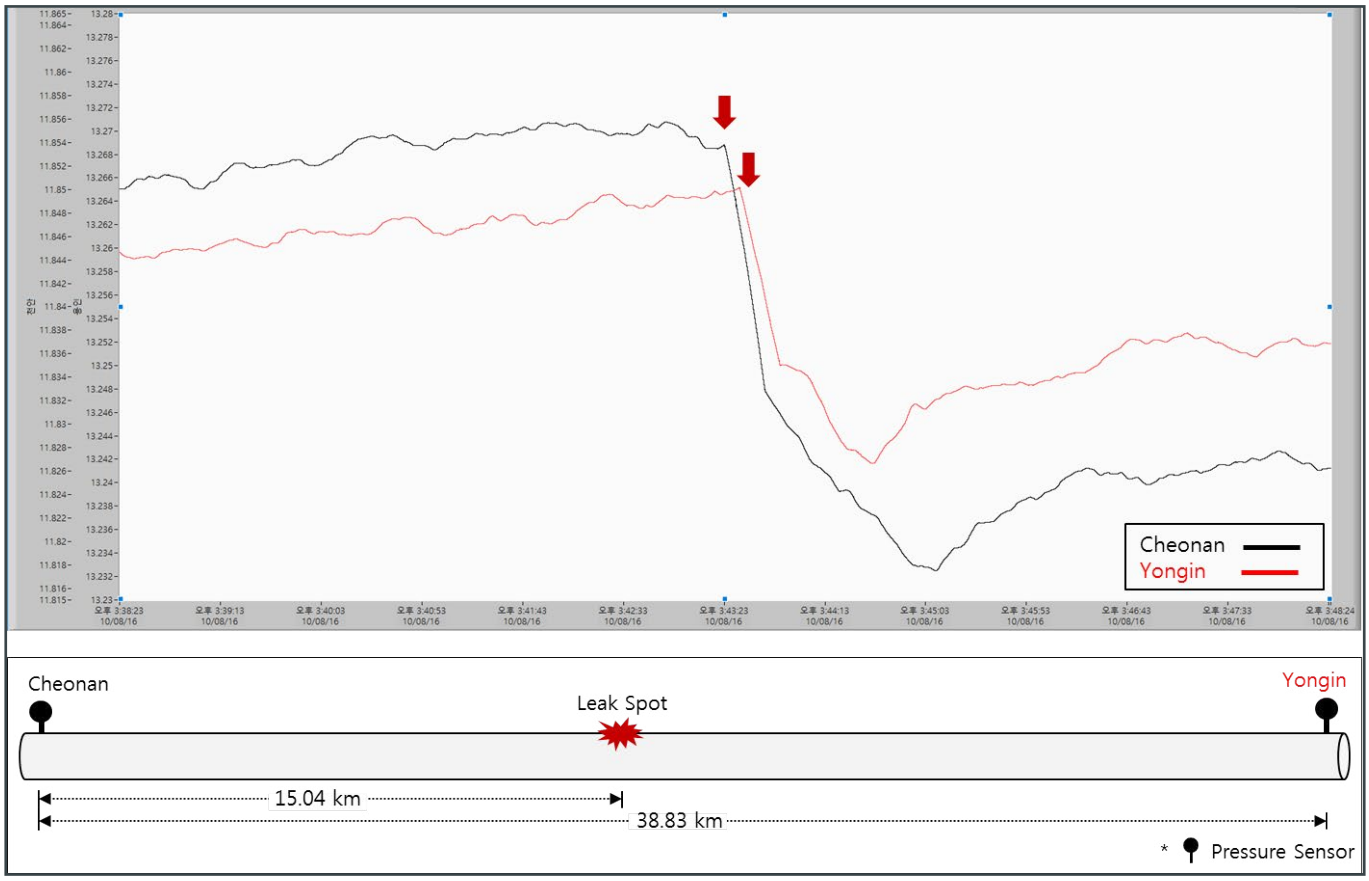

Figure 6: Typical leak pressure trend (after noise filtering)

* 18 inch pipeline with diesel, leak flowrate 1.89 kl/hr, operation flowrate 363 kl/hr

THEORY AND ALGORITHM

LEAK LOCATION CALCULATION

MD-POLIS™ software (S/W) includes the leak spot localizing logic derived from leak detection time differences between two pressure measuring points.

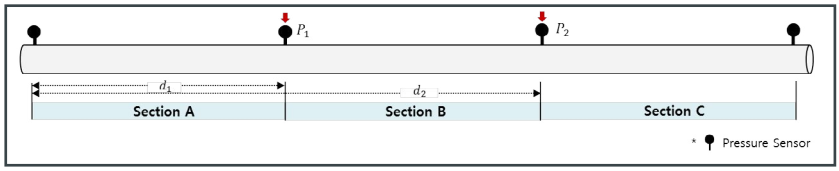

Figure 7: Calculation model for leak spot search

The location detection equation is as follows:

$$\alpha = \frac{|d_1 - d_2|}{v}$$

where α is the reference data defined by a pressure wave propagation velocity and a distance between two pressure measuring points, $|d_1 - d_2|$ is the distance between P_1 and P_2, v represents a pressure wave propagation velocity. Pressure wave propagation velocity refers to the operation velocity at which a pressure waveform is delivered into the fluid inside the pipeline. By comparing this α value with the detection time difference, MD-POLIS™ can predict the leak outbreak section (A, B, or C area on Figure 7). The comparison factor, δ, is defined as follows:

$$\delta = \frac{t_1 - t_2}{\alpha}$$

where t_1 and t_2 are leak detection time of pressure drop at P_1 and P_2 respectively. Client can determine the leak section from δ value and the criteria is explained below.

δ = -1: Leak area A
-1 < δ < 1: Leak area B
δ = 1: Leak area C

Because $|t_1 - t_2|$ is equal to α when leak is occurred in A or C area, B is the only section that MD-POLIS™ can calculate the location of leak. The leak spot localization equation in area B can be derived as:

$$\chi = \frac{1}{2}[(d_1 - d_2) - v \times (t_1 - t_2)]$$

where χ indicates how far away is the leak spot from P_1 in a P_2 direction.

A notable feature of pipeline thefts in Korea is that it is an enterprise type with professionalism. They are attempting to build unterdround tunnel and camouflaged workshop with buildings at a loation far from the pipeline.

Soonho Jeong

LEAK LOCALIZING CALIBRATION LOGIC

Accurate recognition of the pressure drop starting point is essential for localizing. However, in case of theft detection, it is very difficult to accurately grasp the pressure drop point when a professional theft open or close the theft valve very slowly to avoid sudden changes of internal pressure. So MD-POLIS™ includes extra calibration logic in order to minimize the error from the mismeasurement of pressure drop point.

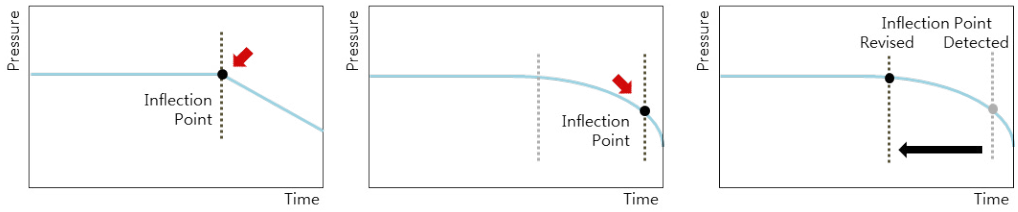

Figure 8: Inflection points according to the graph shape and calibration method

Graph (a) in Figure 8 shows pressure trend, inflection point while the theft valve is opened quickly and (b) shows the trend while the valve is opened slowly. As shown in the Figure above, the inflection point calculated by LDS in (b) is displayed to the slightly right side of the real inflection point. Therefore, it is necessary to move the calculated inflection point to the left as shown in (c).

LEAK DETECTION CALIBRATION LOGIC

Leaks may occur while the pressure in the pipeline rises. In this case, as shown in Figure 9, the pressure drop is not remarkable compared to the amplitude of the noise. Therefore, the pressure graph is rotated horizontally and the compensation logic is applied to amplify the pressure drop. In fact, DOPCO has found leaks that were not detected before this calibration.

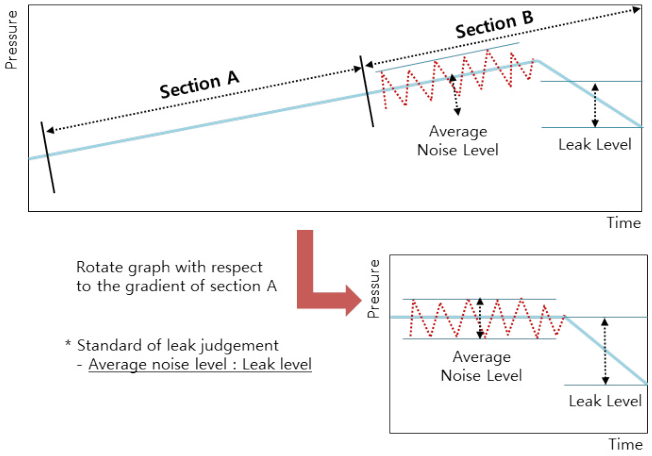

Figure 9: Rotation of a pressure trend graph for leak detection calibration

MD-POLIS™ SYSTEM CONFIGURATION

HARDWARE (H/W)

MD-POLIS™ equipment is designed as a carrier type for easy movement. The H/W consists of a data measuring device and a receiving device as shown in Figure 10.

The measuring device consists of pressure sensor, Remote Terminal Unit (RTU), LTE Modem, GPS and so on.

This device measures pressure and time, and then sends the data to the receiving device via RTU.

The threaded pressure sensor can be combined outside of the pipeline

after removing existing equipment such as pressure gauge without welding.

The receiving device (client) obtains not only instrument operating information that can affect pressure data and properties of the fluid from the D-POLIS™ server but also the data measured at the two sensors.

If operator has a separate power supply, this power supply can be used to operate MD-POLIS™. If not, MD-POLIS™ can be driven by automotive battery or custom battery packs for 24 hours.

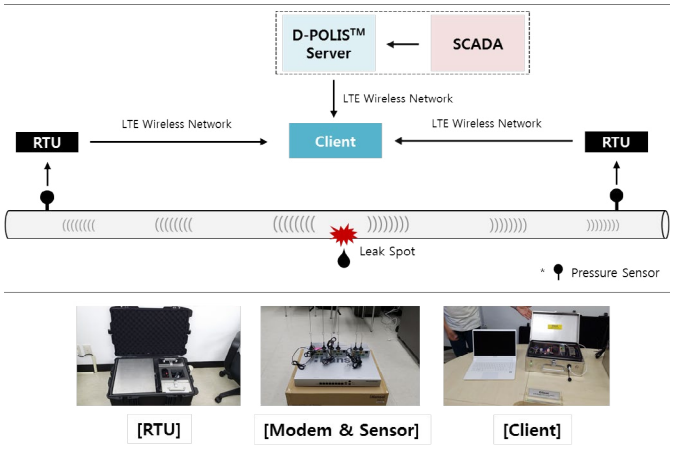

Figure 10: H/W components of MD-POLIS™

SOFTWARE (S/W)

The pressure data from both sensors is transmitted every 1 millisecond over LTE network and the client receives and displays the information. User configuration screen is shown in Figure 11.

In the upper left side of user screen, real time pressure data from two sensors are plotted in different colors. When the suspicious pressure drop is detected, estimated location and time of pipeline leak are appeared in the right side of the screen, and leak location is indicated with an arrow on the batch tracking line. User can get more accurate information by fine tuning with hand calculation function.

To calculate and indicate the suspected leak spot, accurate fluid property data is required, especially the fluid density of the pipeline. Because DOPCO's pipeline transports various oil products across a single line, fluid properties keeps changing depending on the product transferred at a certain time.

Therefore, the product information over time must be registered beforehand in the system and is shown on the bottom of the screen.

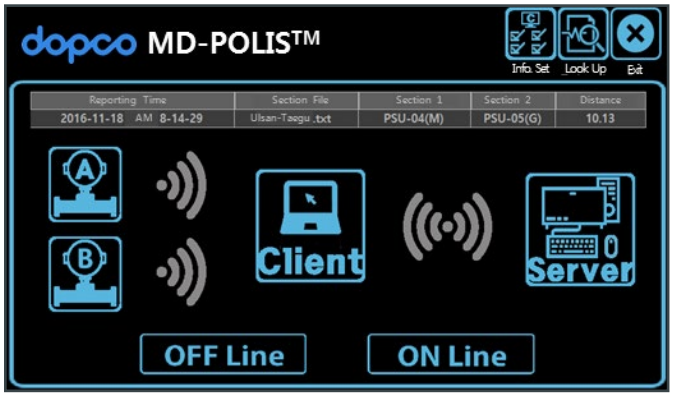

Figure 12: Communication state screen between RTU and client, client and server

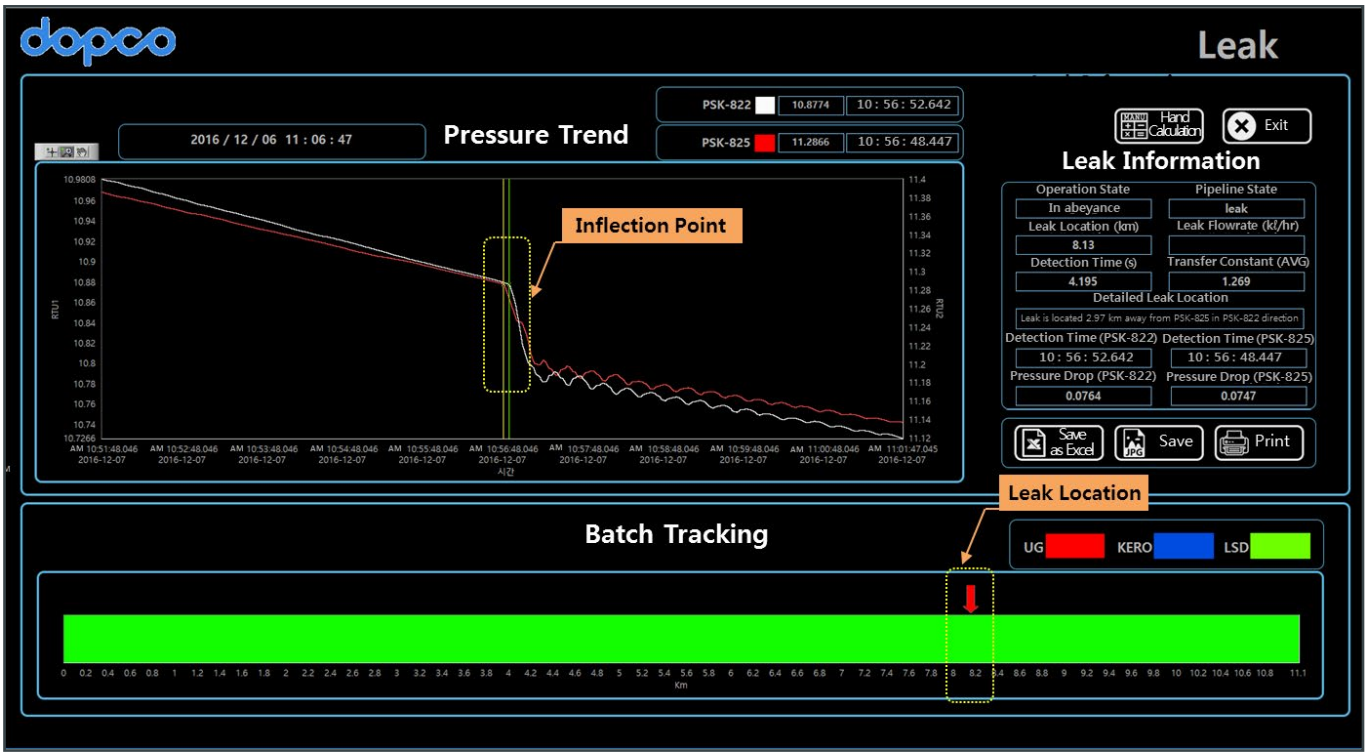

Figure 11: User screen of MD-POLISTM

PERFORMANCE TEST

TEST PROCESS

This performance test was implemented in two cases, in operation and non-operation. Figure 13 shows the test apparatus.

First, the operator installs the precise pressure sensor in the valve box at both ends of the subject area. After the MD-POLIS™ setup is complete, a hose is installed at any valve box between the two measurement points to imitate the oil pipeline theft situation. To maintain and check a low flowrate inside the pipeline, the portable mass flowmeter is installed in the middle of the oil leak hose. At the end of the hose, a tank truck is connected to store the discharged oil. The leakage duration time is 5 min and controlled by valve attached on the hose.

TEST OUTLINE

The object of this test was confirming leak detection performance, localization accuracy, false alarm filtering and the test outline is stated below.

- Pipeline diameter: 10 inch
- Section length (distance between two sensors): 11.1 km
- Leak spot: 2 cases (0.35 km, 8.11 km apart from sensor A)
- Test case: 2 cases (operation, non-operation)
- Internal pressure, internal flowrate (operation): 10~20 kg/cm², 283 kl/hr
- Pipeline volume (non-operation): 564.38 kl

* Other variables (elevation, temperature etc.) are not considered except pipeline volume and internal flowrate

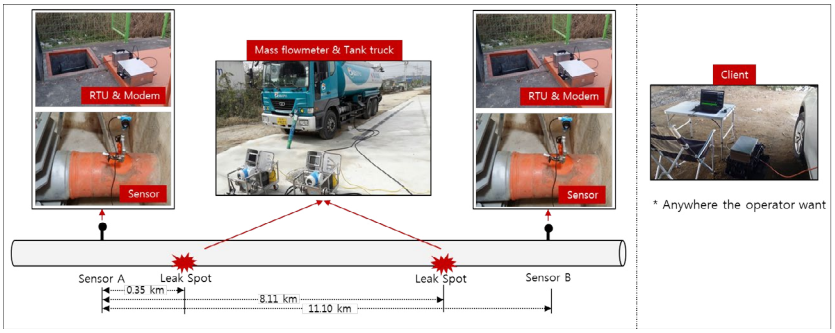

Figure 13: Test scene and apparatus

Leak spot distance from sensor A	Leak flowrate	Leak flowrate (%Vol)	Average localization accuracy
0.35 km	1.90 kl/hr	0.67 %	138 m
	1.50 kl/hr	0.53 %	18 m
	1.30 kl/hr	0.46 %	18 m
	1.09 kl/hr	0.39 %	-173 m
Average of absolute value			86 m
8.11 km	1.96 kl/hr	0.69 %	270 m
	0.62 kl/hr	0.22 %	-50 m
	1.32 kl/hr	0.47 %	-220 m
Average of absolute value			180 m

Table 1: Test results during operation (internal flowrate 283 kl/hr)

Leak spot distance from sensor A	Leak flowrate	Average localization accuracy
0.35 km	1.44 kl/hr	-200 m
	0.36 kl/hr	190 m
	0.36 kl/hr	10 m
Average of absolute value		133 m
8.11 km	0.36 kl/hr	60 m
	0.72 kl/hr	-130 m
	0.36 kl/hr	70 m
Average of absolute value		87 m

Table 2: Test results during non-operation (internal volume 564.38 kl)

TEST RESULT

Table 1~2 show the test results in operation, non-operation respectively.

During both tests, 100 % of detection rate was proved. The false alarms did not appear during test because it filtered out the pressure drop occurred by other equipment operations received from the D-POLIS™ server.

Performance differences based on the distance of the test section were also tested and the results are shown in Figure 14.

While leakage occurred at 11.00 km away from Cheonan, the pressure drop of Cheonan, Pangyo (65.51 km away off the Cheonan) and Yongin (38.83 km away off the Cheonan) was compared. Consequently, the closer the distance between the sensor and the leak point is, the more prominent the pressure drop trend due to leakage. Also, since the noise around Yongin is smaller than that of Pangyo, the pressure drop in Yongin is relatively clearly distinguished.

This allows MD-POLIS™ to detect and locate more accurately than D-POLIS™. Therefore, MD-POLIS™ can be installed and operated at desired location and time, so that even smaller leaks which cannot be detected by conventional fixed D- POLIS™ can be detected.

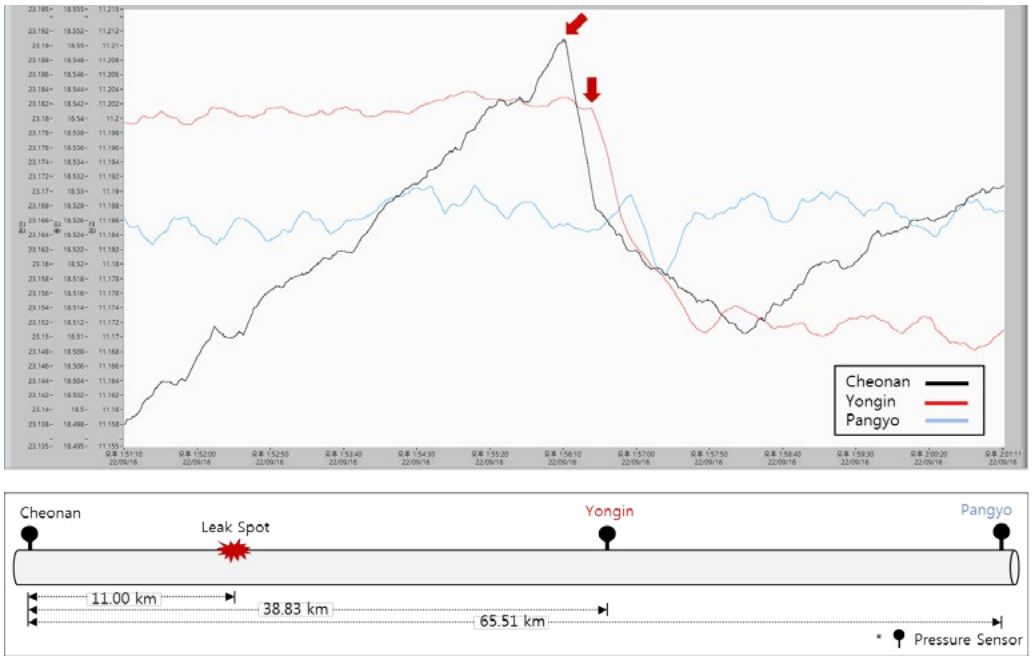

Figure 14: Comparison of pressure trends according to section distance

* 18 inch pipeline with gasoline, leak flowrate 2.45 kl/hr, operation flowrate 757 kl/hr

CONCLUSION

MD-POLIS™ is capable of temporary installation and surveillance in certain suspicious areas for especially the theft detection, and it is also possible to build low- cost, short-term LDS in the absence of conventional fixed D-POLIS™.

By narrowing the detection interval, the detection accuracy can be increased and operators can monitor the areas where D-POLIS™ is difficult to detect. In addition, with the combination of MD-POLIS™ and D-POLIS™ the leak detection performance could be improved.

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Object oriented implementation & maintenance of pipeline SCADA and applications

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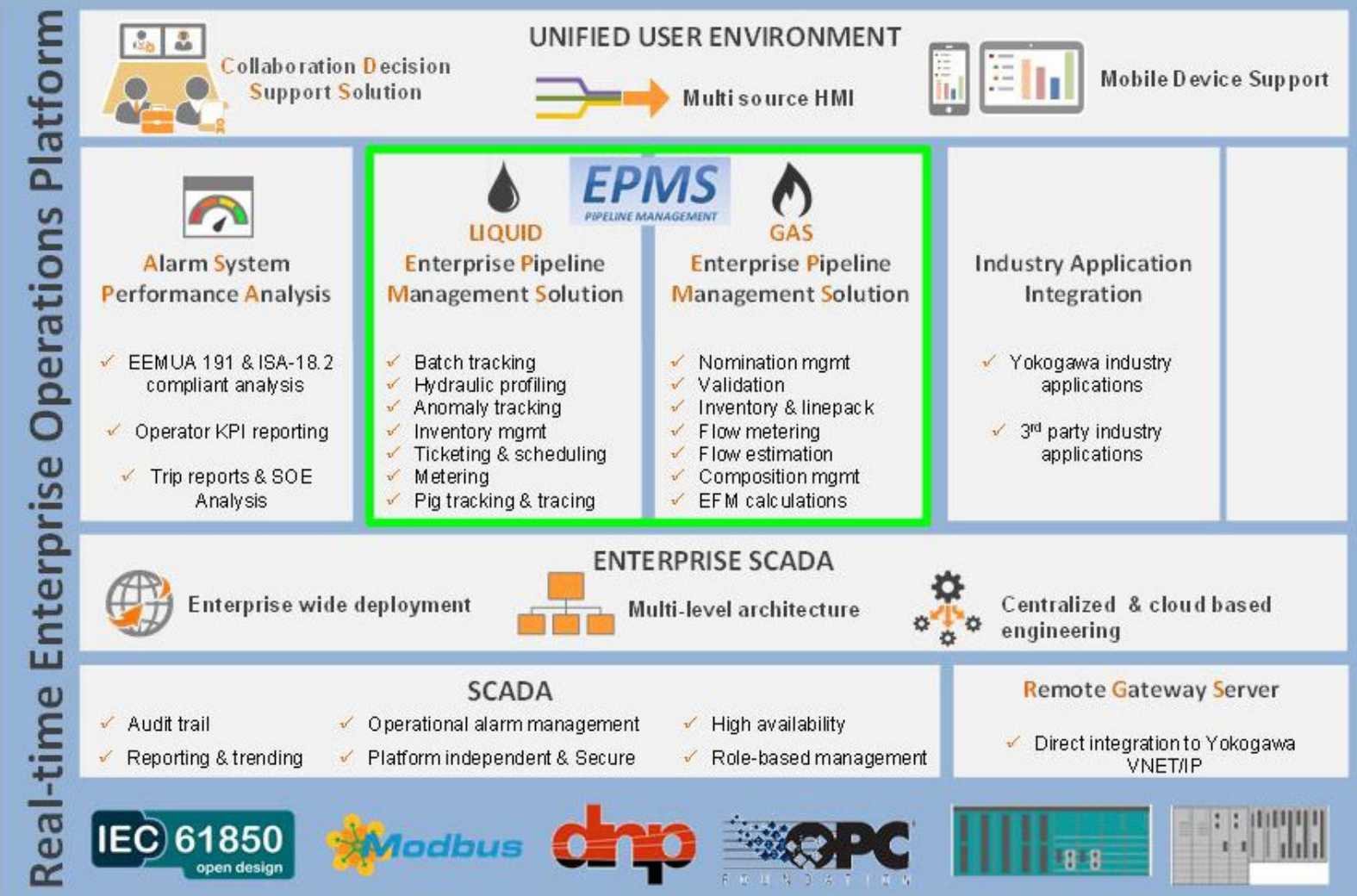

Abstract:

For the operation of a pipeline being able to operate in a safe and reliable way are basic conditions. A SCADA system together with additional supporting pipeline applications like leak detection, metering, mass balancing, pump and compressor management and batch scheduling & tracking play a crucial role in enabling this and are part of a Pipeline Management System (PMS). Main KPIs for implementing and operating these systems are cost and risk.

Although attempts have been made by pipeline operators to define an object oriented IT infrastructure for the PMS following the pipeline (grid) topology it seems that only partial solutions, which don't use a common definition structure, have been developed. These developments seem to be driven from an IT perspective without including the required elements in the OT environment, but do come with the typical issues of an IT implementation.

A crucial element in the PMS development would be having a configurable and truly object oriented SCADA environment following the physical pipeline (grid) topology with integrating standard pipeline applications and hence managing part of the crucial IT/OT integration.

In this paper a development of such an environment is described. Elements like the conceptual setup, integrated functions, implementation methods, operational support and maintenance of the system incl. handling extensions of the pipeline (grid) are described together with the (perceived) advantages compared with more conventional approaches.

INTRODUCTION

The world around us is changing. This not only applies to the economic situation and related welfare distribution around the world, but also to the awareness that human behavior has an impact on the planet and our environment. For the collection and distribution of liquid and gaseous materials it is expected that pipelines will remain an important mode of transportation for the years to come.

This doesn't automatically mean that nothing is changing though. This is partially due to the aforementioned awareness about the impact on the environment of our behavior, but also to the fact that we're getting used to having information available at our finger tips any moment of the day. Overall this leads to a number of attention areas in today's pipeline operation. Some important ones include:

1. **Process safety & asset integrity.**
   The awareness is increasing that incidents leading to spills, injuries or even fatalities can be prevented or the consequences limited if the right precautions are implemented. This also applies to pipelines where modern technologies provide the means to do so.
2. **Environment.**
   Spills from pipeline leaks or greenhouse gas emissions related to pipeline operations have never been acceptable, but for several reasons there is more attention for them.
3. **Reliability & availability.**
   In most cases pipeline operators are not the owner of the products transported in their pipelines. Contracts between the owner of the product(s) and the pipeline operator are in place. These contracts not only arrange the mutual obligations, but also the penalties involved if these obligations aren't met. Penalties to be paid by the operator are due if he isn't able to deliver as promised i.e. if the pipeline isn't available when the operator is contractually obliged to.
4. **Efficiency.**
   Being as efficient as possible with the lowest cost as a result is always important, but pipeline operators not always are without competition. This means that efficiency and the related costs have an impact on the sales price bandwidth and the resulting margin. Examples of attention areas for efficiency are energy reduction or better operability e.g. by OT/IT integration.
5. **Meeting end-user's expectations.**
   Customers of pipeline operators are operating in a competitive environment in which margins are low and decisions have to be made near to real-time based on accurate information. This means that customers have requirements related tometering, mass balancing, flexibility, ease of use and batch related losses for example.

For pipeline operators it is important to identify which attention areas are of importance and how to these attention areas should be addressed. There is no one size fits all approach as elements like commercial environment, pipeline system status and local regulations differ from operator to operator. There are a number of challenges associated to the attention areas that pipeline operators may encounter. These challenges are often related to the pipeline automation requirements.

With the aforementioned attention areas the following challenges, which are somehow related to automation, are associated:

1. **Changing and stricter regulations that require changes in the supporting systems.**
   Examples of this kind of regulations include:
   - Related to flaring of natural gas during repair works;
   - Safety requirements for high pressure hydrocarbon pipelines leading to the requirement of setting up a Technical Safety Management System to be approved and supervised by the relevant authority.
2. **Ageing assets and related risks.**
   Many pipeline systems have old elements in them. They not only have a higher risk of failures, but often also are more difficult to inspect.
3. **Ageing workforce and related loss of knowledge and capabilities.**
   Pipeline operators and people in the supporting departments often have grown with the operation and know the situation inside out. This allows them to prevent things from going wrong or escalating if something unexpected happens. How to overcome the underlying issue needs to be answered. Possible solution directions include training people in time to have them up to speed when people retire and/or implementing supporting technology that not only performs certain logic to provide insights and execute tasks, but may also allow further optimization of the operation and prevent incidents from occurring.
4. **Balance between revenue and costs in order to stay competitive as a business and profitable.**
   Variations and shifts in supply and demand of the transported products may lead to a situation where costs have to be covered by a smaller amount of product transported and hence a higher cost per transported unit. Not always this type of change can be covered by an increase of tariffs.
5. **Requirements for additional data and changes to the way these data are expected to be made available.**
   IoT, smart devices, big data, cloud, mobile devices and augmented reality are examples of developments that are happening fast and may have an impact on requirements for pipeline operators. Another aspect is the expectation to have data available in a near to real-time manner, because of business requirements (e.g. hourly management of the gas business).

IoT, smart devices, big data, cloud, mobile devices and augmented reality are examples of developments that are happening fast and may have an impact on requirements for pipeline operators.

Martin te Lintelo

These attention areas with the related challenges require information to be made available to the right people, systems and/or applications at the right moment in order to manage the underlying processes that keep the performance indicators within the right bandwidth.

This situation has grown over the years and pipeline operators have reacted by implementing supporting systems, which have been performing sufficiently over the years. For a number of reasons these systems are due for a (partial) replacement or require an upgrade. These reasons include:

1. **Bespoke systems for which it is impossible or too expensive to maintain them.**
   Some of the pipeline management systems (PMS) used by pipeline operators are based on a monolithic software solution developed for the unique requirements of the customer. They're often developed based on outdated software development platforms and/or outdated computer platforms and operating systems. On top of that the people that know the specific application and have supported it for many years are retiring and are not replaced by younger people with the same knowledge, skills and application knowhow.
2. **Phased implementation of additional software-based support tools on top of or around a basic system that isn't capable of supporting a modern, standards-based implementation.**
   With the growing number of challenges comes the requirement for additional functionality in the supporting tools. This functionality is often offered by companies with specialized software tools. These tools are developed on the latest platforms with a view to be able to support them for the years to come and in a way modern software tools communicate with each other. Supporting systems developed on older platforms or communicate with them isn't always possible or can be considered too expensive.
3. **Cyber Security.**
   For different reasons an increasing number of Pipeline Management Systems is connected to the internet. The related benefits can be big and outweigh the risk of attacks, damage or unauthorized access that are possible when being connected to the internet.
   Cyber security solutions are developed for systems currently supplied to the market and not always support old systems. In general operating system (OS) security patches also aren't available for OS versions that aren't officially supported anymore. Keeping a PMS secure means that it has to be based on a recent enough platform and OS. For the popular Microsoft Windows platforms this means for example that upgrading is required roughly every 7 years.

In the remainder of this paper a PMS development approach is described using a modern software environment that addresses the KPIs (lifecycle) costs and (deployment) risk, while being able to manage the requirement of dealing with the existing OT environments of pipeline operators.

CONCEPTUAL SETUP OF THE SOLUTION

INTRODUCTION

A modern PMS should have a standardized system foundation, in which applications can be plugged into in a modular way, as well as a design to ensure interoperability with the IT environment and the related policies. A graphical representation of such an environment is shown in the figure below.

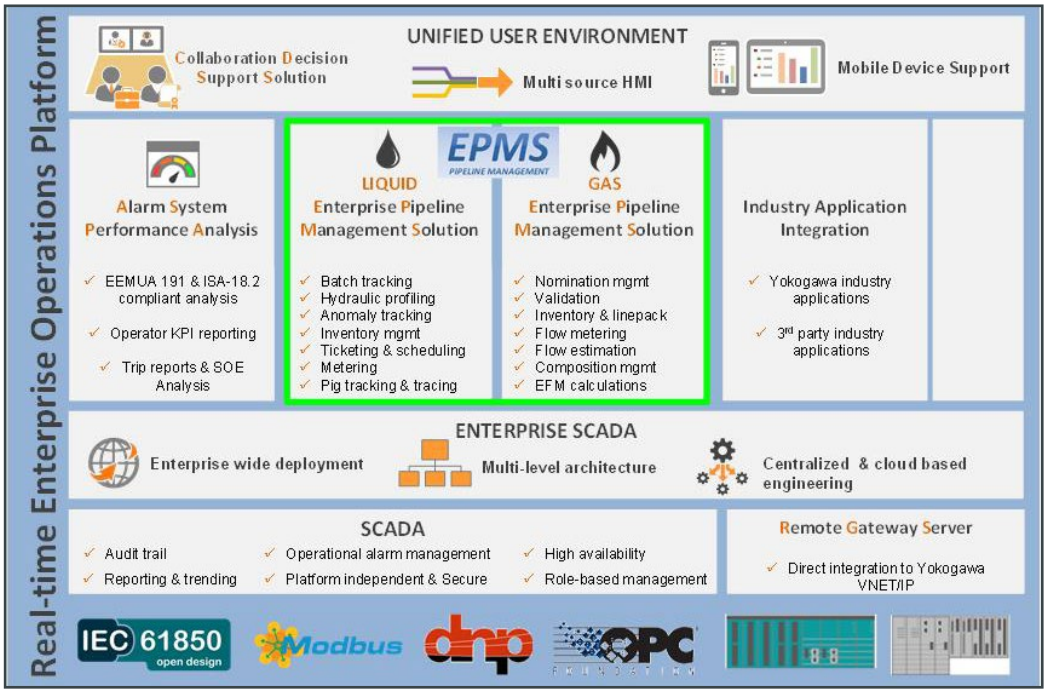

Figure 1: A graphical representation of a modern Pipeline Management System environment

Depending on the size of the pipeline system and the development history, the number of devices to interface with in the OT layer can vary. Allocating budget and time to replace the devices in the OT layer or upgrading them isn't

that easy. Costs shouldn't be underestimated and finding the right timing for the actual work required in the field isn't easy as well. This means that a modern PMS should also allow for a flexible IT/OT integration approach in order to be able to interface with many different metering, control and safety systems based on a wide variety of protocols and requiring communication bandwidths fitting with the infrastructure in place.

Adding to the costs and risks of the deployment of a PMS are also the people involved. Man hours can be a fairly expensive part of the deployment and making sure that people with the right knowledge and skills are available locally for maintenance, upgrades and extensions is important as well to reduce the deployment risk.

Therefore it is beneficial that a PMS development environment allows for the reduction of the number of required deployment hours and enables a quick learning curve to master the system.

An object oriented development approach is quite common nowadays and has proven to make it easier to understand and deploy software solutions. With that the object oriented approach helps reducing the number of deployment hours and the related costs and risk. Using an object oriented approach for a PMS development therefore seems logical, but for some reason there don't seem to be development environments available that use this approach for both the IT and OT environments in conjunction. Individual software solutions developed by different companies use an object oriented deployment approach, but the object orientation isn't shared with other pipeline software solutions that the software solution has to cooperate with in an overall PMS. This doesn't always allow pipeline operators to select the best software solution for a specific function.

In the remainder of this section an object oriented approach for a PMS in which the pipeline applications are integrated with the SCADA system that handles the integration to the OT environment.

TYPICAL LAYERED ARCHITECTURE OF A PIPELINE MANAGEMENT SYSTEM

Like for other automation solutions in which the business operations depend on regular updates regarding measurements in the production processes, a typical pipeline automation system has a layered structure with levels from field devices through control layer to SCADA, supervisory applications up to the business systems of which the nomination handling is a typical part of.

A general description for this kind of layered system is described in the S95 standard defined by the ISA. S95 identifies 5 levels from 0 to 4 with level 0 being the actual process and level 4 representing the business systems, sometimes also

A modern PMS should have a standardized system foundation, in which applications can be plugged into in a modular way, as well as a design to ensure interoperability with the IT environment and the related policies.

Martin te Lintelo

referred to as order to cash. In between are the field level for sensing and manipulation, the automation of the production process with the monitoring and supervisory control, and the layer for translating customer orders to actual production execution and maintaining records for the financial management and optimization purposes.

For a typical modern PMS a representation of the layers is shown in the figure below.

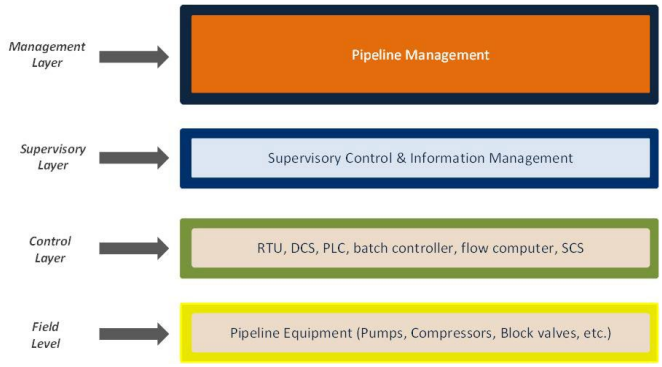

Figure 2: A typical layered structure of a modern Pipeline Management System

The communication to the field level is handled by the control layer that can also include devices that collect custody transfer type data. For interfacing configuration is required on both the SCADA (IT) and the control and field (OT) side. The selection of where to include (near to) real-time automation has to be made as part of the overall PMS design.

PIPELINE NETWORK REPRESENTATION

A network can be represented as a number of vertices connected by nodes. By representing networks this way, from very simple straight line pipelines without branches to the most complex grids can be represented.

The vertices can have all kinds of static and dynamic properties, which can either be measured or derived from measured parameters. If not enough parameters can be measured accurately enough these properties can be estimated as well.

The nodes can represent any kind of process and related behavior from simple block valves to complex terminals. Important is the number of connections (inlets or outlets) to other nodes. Depending on the requirements not all the pipeline segments

Having a unified user environment for both SCADA and pipeline management functions based on common foundation blocks. This reduces the risks of costly mistakes and the need for additional training.
Martin te Lintelo

need to be represented. One can imagine that not all the small pipelines and bypasses in a compressor or pump station need to be included for the purpose of supervisory pipeline monitoring and the same applies to details of manifolds in terminals.

INTEGRATED FUNCTIONS

For a specific pipeline operation the group of pipeline management functions used mainly depends on the type of product transported in the pipeline system, but also on the position and function of the pipeline in the supply chain. In general the categories of functions are commercial aspects incl. the related planning, process safety and asset integrity, environmental damage and operational efficiency. Sometimes a specific function serves more than one of these categories.

The following functions are typically found in pipeline management systems:

- For liquid pipelines:
  1. Leak detection
  2. Delivery scheduling
  3. Batch tracking incl. routing, and interface management
  4. Meter ticketing
  5. Inventory management
  6. Mass balancing incl. reconciliation
  7. Pump management
  8. Anomaly management / pig tracking

- For gas pipelines:
  1. Leak detection
  2. Nomination management
  3. Metering incl. supporting calculations and data collection
  4. Composition monitoring
  5. Line pack and balancing (incl. reconciliation)
  6. Compressor management
  7. Simulation

Especially for functions requiring an implementation with complex modeling and/or algorithms, the functionality is provided by different software applications that need to communicate with each other and with the SCADA system providing the data and communication to the field. This requires communication between the parties involved regarding the technology to be used for interfacing of the data and tuning of the actual data content.

Some of the functions are (1) related to individual pipeline segments whereas others can only be (2) handled at a supervisory level with data from several segments and related to overall pipeline system.

For the deployment of the functionality it makes sense to have the functions related to individual pipeline segments handled by pipeline segment objects and have the other functions handled at an aggregate level with the data provided by the individual pipeline segment objects.

DEPLOYMENT AND OPERATIONAL ASPECTS

INTRODUCTION

With a view on costs and risk it is important for the deployment of a PMS to not only look at the implementation and maintenance of the system, but also at how the system provides better support for the actual operation of the pipeline system.

In this section is described how this can be achieved with the Enterprise Pipeline Management Suite (EPMS) of Yokogawa.

IMPLEMENTATION AND MAINTENANCE

For the development of the functionality the pipeline network topology is implemented using objects that are similar from pipeline to pipeline. This leads to an intuitive way of representing the pipeline infrastructure.

The configuration for the respective pipeline SCADA and pipeline management applications are done in one engineering environment. The users of the SCADA and pipeline management functions also make use of the same user environment. This user environment provides the flexibility that can be expected from a modern environment.

One example is the possibility to have secure access to the system from a number of platforms incl. mobile platforms that can be used by operators in the field or by management members that are not in the office.

The development is based on defining pipeline segments between two sites. Site specific configuration defines the number of connections of sites and the infrastructure available at sites incl. how the infrastructure can be used. Also the products and their properties have to be defined.

With the definition of the objects several elements incl. the SCADA HMI elements and data definition are created or can be updated. Based on these definitions the connections to the OT environment can be established through configuration. This approach saves engineering time and avoids errors.

A picture of how this is achieved is provided in the following figure.

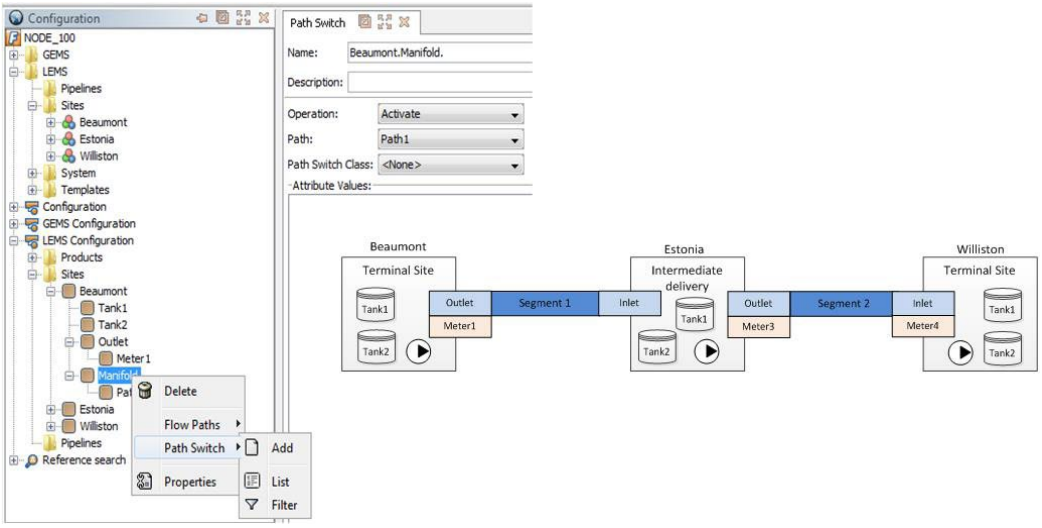

Figure 3: Pipeline topology definition using EPMS

For the typical layered structure of a PMS it means that with EPMS it looks like the picture below in which the management layer and supervisory layer are combined.

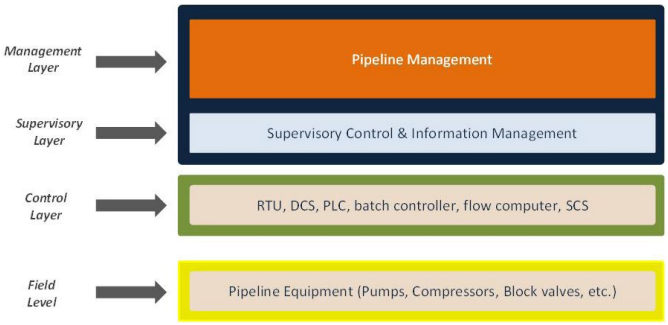

Figure 4: The layered structure of EPMS

Standard integrated pipeline application functions on top of project specific SCADA configuration include nomination handling, batch management incl. anomaly & interface management, ticket management, metering incl. related calculations, inventory & line pack/fill, hydraulic profile monitoring, mass balance based leak detection, liquid/gas inventory management, pump & compressor management, and flow path management at terminals.

These functions are developed based on market research and provide an extensive portfolio. If required, it is possible to extend and enhance them within the object oriented framework. If functions are developed or enhanced project-specific, one choice is to have the functionality remain project-specific or to have the functionality be part of the standard EPMS functionality and have it maintained for future releases. For both options the end-user doesn't lose the deployment advantages that come with the object oriented framework.

It doesn't make sense for all the required functions to be developed within the environment. Therefore it is important to have standards-based open interfaces using a common information model, preferably based on the same definition of pipeline objects.

Next to common information models also standard interface technology like OPC-UA is used, supporting not only peer-to-peer connections in a more sustainable way, but also supporting integration in middleware-based implementations that are becoming common in the industry. This also applies to other applications that need to be interfaced with like nomination handling and ERP software.

Overall the advantages of the deployment using EPMS are:

1. **Extendibility, flexibility and ease of redeployment**
   - Easy parameterization of the standard application suite objects for pipeline- assets and management functions;
   - Common SCADA functions are naturally embedded with the pipeline objects like pipeline segment inlets and outlets, segments, block valves, pumps/compressors and so on;
   - Easy management of future changes and upgrades and portability of applications is enabled;
   - Sufficient capability is intrinsically available to easily adapt templates and functions without having to call up application experts.

2. **Qualitative pre-tested and well documented functionality**
   - Having pre-tested functionality reduces the time for testing and commissioning during implementation of a new PMS new or extension of an existing PMS.

3. **Platform independent application deployment**
   - A single, unified, scalable, flexible, and platform independent environment is provided;
   - Hardware and software platforms have different lifecycle expectations. Managing this aspect is easier facilitated;
   - Ensures interoperability with current IT environments and policies.

OPERATION

For the use of the software during operation of the pipeline system it is important that the applications and other pipeline management functions are consistent in terms of user experience and operational philosophy. This is achieved by having a unified user environment for both SCADA and pipeline management functions based on common foundation blocks. This reduces the risks of costly mistakes and the need for additional training.

For the pipeline operator it is important to manage delivery contracts and associated logistics in the most time and energy efficient manner. Important elements that are supported by EPMS related to this are:

- **Offering sufficient agility to adjust to changing pipeline logistics.**
  When changes are required to the configuration of the pipeline system or the way the operation of the pipeline needs to be done, it is important that the implementation is possible and happens almost unnoticed without interfering with the actual operation and without changing the user experience. Needless to mention that changes need to be made at the lowest costs possible and without introducing any risks for the operation.
- **Facilitate better collaboration and information sharing across disciplines.**
  As the people of different departments use the same applications and user environment, it will be easier for them to work together for example during calamities. The aspect of a reliable near to real-time interfacing of data plays an important role as well.
- **Facilitate the centralized management of all pipeline operational tasks and the audit trails for individual user roles and tasks.**
  To be able to make sure that people have access to the right information at the right time it is easier to manage this from within one pipeline management environment embedded in the overall IT environment than to have this functionality available in a scattered way in different software applications.
  Being able to get insight in an easy way in what actually happened during the operation of the pipeline system makes it easier to manage the continuous improvement of the actual operation and the experience of the users.

CONCLUSION

For the implementation of a Pipeline Management System it is important that the foundation it is built on is right. The foundation has to allow interfacing to both surrounding IT applications and the layers close to the actual pipeline system that actually manage the control and safety of the pipeline system and also provide the required data.

The latter is typically referred to as IT/OT integration, which is part of the wider IIoT (Industry 4.0) concept the business community is talking about more and more as part of their strategic directions.

With EPMS it is proven that it is possible to develop the SCADA and pipeline application layers in an object oriented and integrated manner following the pipeline system topology. This will support the deployment i.e. implementation and maintenance of Pipeline Management Systems with lower costs and risks.

With EPMS a methodology and framework is available to enhance and increase the functionality in case requirements are different or have increased.

Not for all pipeline management functions it can be appropriate to develop them within the current framework. Therefore it is important to make the deployment of these functions together with an environment like EPMS easier and with less risks and costs. This can be achieved by working on a standard definition of the required objects used across applications and the availability of standard interface methods like OPC-UA.

Yokogawa is open to work with partners on the further enhancement of the pipeline application suite either by integrating pipeline application functionality in EPMS or by working on a standard definition of pipeline objects and open standards based interfaces, which will allow end-users to have the best functionality that is available with the advantages that the framework offers.

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Advert Deadline: April 7th 2017

INTERVIEW:
MAATS DISCUSSES THE 12. PIPELINE TECHNOLOGY CONFERENCE PTC

The 12th Pipeline Technology Conference (taking place 2-4 May 2017 in Berlin, Germany) will attach great importance to pipeline construction topics and companies. For this reason, the International Pipe Line & Offshore Contractors Association, IPLOCA, will hold its regional meeting for central Europa in conjunction with the ptc. We have asked Paul Waanders, international sales manager Maats Pipeline Equipment about the motivation of being part of this year's ptc and what pipeline construction companies expect.

What was your reason to exhibit at the ptc 2017?

MAATS has been looking for a few years for a possibility to showcase its capabilities to its customers in Europe. As we are mostly into pipeline construction and this is a niche market, we found there was not a lot to choose from.

Is there no event in Europe for your business?

Not really, we participated in the BAUMA exhibition in Munich and visited the Intermat in Paris, but these are general construction equipment exhibitions where we felt kind of "lost". Then there are some events that focus on all aspects of pipeline operation, like corrosion- and integrity management, leak detection and inline inspection. Basically events like the ptc. These are however all technologies used after commissioning of a pipeline. But that is not where our business is, we are on the construction side, the part before commissioning of a pipeline!

But still you are at the ptc?

Some time ago we were asked by the ptc to join the event but then shared our concerns that the topics are not really in line with our business. We started a discussion and after some meetings we found the ptc willing to extend their focus, or in fact add a focus: "pipeline construction". With attracting not only some exhibitors from this field, but also our clients and target group the oil and gas operators, this might be the start of the European event for pipeline construction. That is also why we hope that many companies from our field of work will join us!

What do you expect?

MAATS' philosophy is that, if you want to change things, you have to show initiative and sometimes stick your neck out. Surely the "pipeline construction"-side of the ptc will have to evolve over time but the event is in its 12th year and with about 600 attendees and some 65 exhibitors from the industry last year, the ptc could give "our" track a jump start. Moreover we were lucky to find Mannesmann Engineering & Construction GmbH willing to organize a regional meeting for the International Pipe Line and Offshore Contractors Association (IPLOCA) at the same time, at the same venue. Bringing these two events together contributes to the goal of brining the industry together.

All good then?

As a manufacturer, seller and renter of pipeline construction equipment, you like to show your capabilities. In our case that is our bending machines, welding tractors and pipe layers. Although the current venue at the Estrel Hotel in Berlin is really excellent, with hotel, exhibition and meeting rooms all under one roof, it is not possible to bring one of our machines, they are simply too heavy. On the other hand: not bringing any heavy machinery is a big save on the exhibition budget!

Where will we find you?

We will be at stand no. 70 from the 2nd thru the 4th of May

WELCOME TO THE 12TH PIPELINE TECHNOLOGY CONFERENCE

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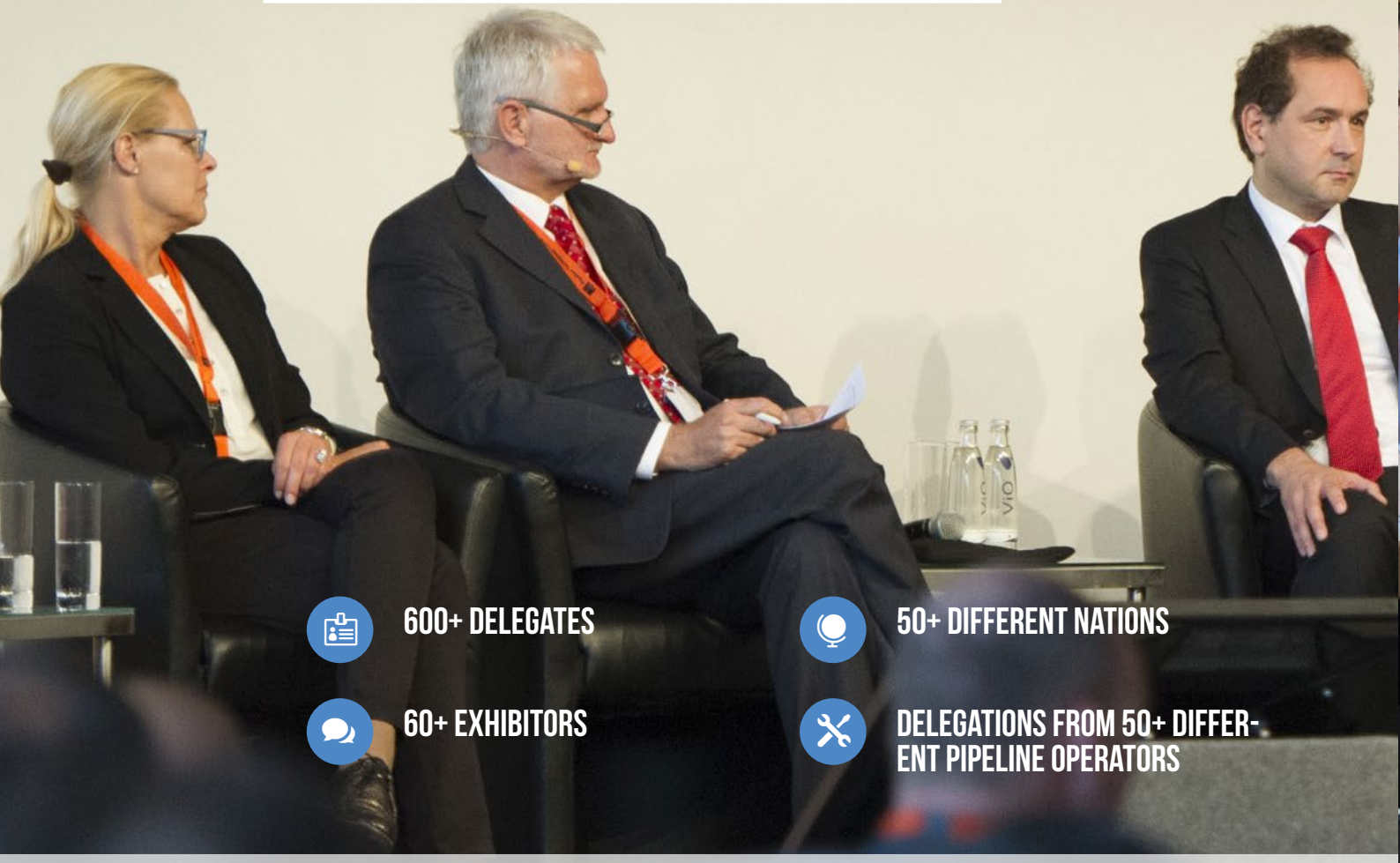
PREVIEW



- 600+ DELEGATES
- 50+ DIFFERENT NATIONS
- 60+ EXHIBITORS
- DELEGATIONS FROM 50+ DIFFERENT PIPELINE OPERATORS

CONFERENCES / SEMINARS / EXHIBITIONS

From 2-4 May 2017 Europe's leading pipeline conference and exhibition, the Pipeline Technology Conference, will take place for the 12th time. The 12th ptc offers again opportunities for operators as well as technology and service providers to exchange latest technologies and new developments supporting the energy strategies world-wide. More than 600 delegates are expected to attend the 12th ptc in Berlin.

The practical nature of ptc was always based on the cooperation with our technical and scientific supporters and on a top-class international advisory committee. The conference will feature lectures and presentations on all aspects surrounding oil, gas, water and product pipeline systems. One of the focus topics at ptc 2017 will be "Pipeline Construction".

Please take a closer look into the Confernce Program and get involved now - register as conference delegate or reserve your booth at the accompanying exhibition. (www.pipeline-conference.com)

I am looking forward to hearing from you!

Yours,

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

Tuesday, 2 May 2017

	Track 1	Track 2	Track 3	Track 4	Track 5	Exhibition
08:00						
08:30						
09:00	Registration Coffee in Exhibition Hall					
09:30						
10:00	Opening					
10:30	Keynote Speech					
11:00	Opening Panel Discussion					
11:30						
12:00						
12:30	Lunch Break in Exhibition Hall					
13:00						
13:30						
14:00						
14:30	1.1 Safety (by DVGW)	2.1 Inline Inspection	3.1 Auto-mation	4.1 Trenchless Con-struction	5.1 Repair	
15:00						
15:30						
16:00						
16:30	Get together in Exhibition Hall					
17:00						
17:30						
18:00						
18:30						
19:00						
19:30						

Wednesday, 3 May 2017

Track 1	Track 2	Track 3	Track 4	Track 5	Exhibition
1.2 Offshore Tech-nologies	2.2 Inline Inspection	3.2 Leak Detection	4.2 Con-struction	5.2 De-commis-sioning	
Coffee Break in Exhibition Hall					
1.3 Offshore Tech-nologies	2.3 Integrity Manage-ment	3.3 Leak Detection	4.3 Con-struction	5.3 Composite Repair	
Lunch Break in Exhibition Hall					
1.4 Standards & Regu-lations	2.4 Integrity Manage-ment	3.4 Leak Detection	4.4 Planning & Design	5.4 Coating	
Coffee Break in Exhibition Hall					

Dinner Invitation

Thursday, 4 May 2017

Track 1	Track 2	Track 3	Track 4	Track 5	Exhibition
World Pipeline Outlook					
Coffee Break in Exhibition Hall					
Closing Panel Discussion					
Closing Remarks					
Lunch Break in Exhibition Hall					

Post-Conference Workshops

1) Pipeline Leak Detection

(free for ptc delegates)

5 - 6 May 2017
Post-Conference Seminars

1) In-Line Inspection of Onshore and Offshore Pipelines

2) Geohazards and Geotechnics in Onshore and Offshore Pipeline Engineering

(additional registration required)

IPLOCA WILL HOLD ITS REGIONAL MEETING IN CONJUNCTION WITH PTC 2017

- The regional meeting will take place at the Estrel in Berlin on 2 May 2017.
- This regional approach allows guests to engage at the local level and discuss common issues and concerns. The meeting includes presentations from IPLOCA and invited guest speakers. All delegates of the meeting will also be invited to visit the **exhibition** of the 12th Pipeline Technology Conference (ptc).

CONFERENCE PROGRAM

TUESDAY, 2 MAY 2017

09:00-10:00 Registration *(Foyer Hall A/B)*

10:00-10:30 Opening *(ECC Room 1)*

Welcome

Klaus Ritter, President of EITEP Institute, Germany

10:30-11:00 Keynote Speech "Energy Cooperation Across New Walls in Europe" *(ECC Room 1)*

- Stability of energy networks within Europe
- The sector coupling between power and gas - a new optimization opportunity
- BREXIT - the consequences for the European internal market
- Improved flexibility with hub cooperations or mergers

Keynote Speech

Stephan Kamphues, Member of the Board of Management, Open Grid Europe, Germany / President, ENTSOG - European Network of Transmission System Operators for Gas, Belgium

11:00-12:30 Opening Panel Discussion "New Players within Market Areas - New Opportunities for the Energy Customers?" *(ECC Room 1)*

- "All-electric-world" - a critical path for security of energy
- Improving stability of energy networks with more incentives for the cooperation of gas and power operators
- Security of supply and volatility of renewables - unsolved problems and way forward
- More cooperation, less codes and standards - an operators viewpoint
- Solutions with combined European energy marketplaces - only a dream

Session Chair

Heinz Watzka, Senior Advisor, EITEP Institute, Germany

Panelist

Arno Büx, CCO, Fluxys, Belgium

Panelist

Stephan Kamphues, Member of the Board of Management, Open Grid Europe, Germany / President, ENTSOG - European Network of Transmission System Operators for Gas, Belgium

Panelist

Ulrich Lissek, Head of Corporate Communications and Governmental Relations, Nord Stream 2, Switzerland

Panelist

Dr. Joachim Pfeiffer, Economic and Energy Policy Spokesman for the CDU/CSU Parliamentary Group / Member of the German Parliament, Germany

12:30-14:30 Lunch Break in the Exhibition Hall

+ Scientific Advances Poster Session (14:00-14:30)

See the whole program of the ptc at: www.pipeline-conference.com/program

Core Statements from ptc 2016

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".

Fouad Mohamed,
Construction Enginner at Kuwait Oil Company

"This is my 1st time in the pipeline technology conference. I think it's a very good opportunity to meet people and share experience and I think I will attend it every year. It is very useful to see other business and technology partners. It is really a good gain for everybody".

DO YOU AGREE WITH THESE STATEMENTS?

Serhil, Konovalov
Global Energy / O&G Lead / IoT Solutions Group - Cisco Systems Inc.

"IoT technologies are demonstrating real economic impact to improve integrity and safety of pipeline operation. However, the lack of operational Cyber Security capabilities puts breaks on innovation and new business opportunities. I believe that pipeline industry like no other, has tremendous potential to harvest benefits of IoT and bring cyber threats under control. Big thanks to ptc and EITEP for leading these important discussions".

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".

PLEASE LET US KNOW YOUR THOUGHTS

MAIL TO: PTJ@EITEP.DE

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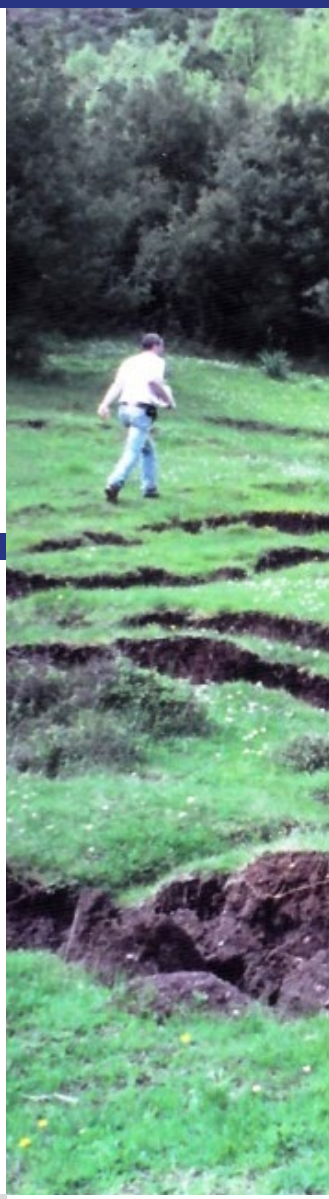
Seminars

In-Line Inspection of Onshore and Offshore Pipelines

Geohazards and Geotechnics in Onshore and Offshore Pipeline Engineering



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JERA

Takashi Anamizu
Senior Executive Officer
Tokyo Gas Co., Ltd

Hajime Hirano
Executive Vice President, Group CEO, Energy Business Group
Mitsubishi Corporation

Hirotatsu Fujiwara
Managing Officer, Chief Operating Officer
Mitsui & Co.

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Peter Coleman
Chief Executive Officer and Managing Director
Woodside Energy

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