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Instruments of ptc: ptj and seminars

Dr. Klaus Ritter
Editor in Chief

The "**Pipeline Technology Conference**", ptc is known and recognized worldwide despite its young age of 14 years. It is the most international and balanced Pipeline Technology Conference in the world. Participants and exhibitors come from over 55 countries. They are roughly from the following sectors:

- Operator/Authority/Research (30%)
- planning/building industry (20%)
- Plant and equipment manufacturers (20%)
- Service provider (30%)

More than **120 speakers and participants in discussion rounds** also come from roughly the same sectors. More and more operators come from Asia, Africa and Latin America, because at the ptc in Berlin both the latest technology and the most profound experiences of European operators are presented. As a rule, many more presentations are offered which have already successfully passed the quality check by the international Advisory Committee but which could not be included in the programme. These great papers are among the articles published in the "Pipeline Technology Journal", ptj. The "**Pipeline Technology Conference**" offers primarily a platform for the exchange of the best technical solutions for **Safety, Reliability and Profitability** of pipelines.

The close proximity to operators and the entire pipeline industry, which is particularly evident in the strong Advisory Committee, led us to the realization that it is not enough to focus solely on optimizing the technology. Therefore, the ptc deals with trends and issues that are brought to the fore from outside. These topics are dealt with through keynotes, panel presentations, panel discussions and side conferences. A number of outstanding topics over the past 13 years have been discussed:

- Availability of oil and natural gas/peak-oil
- Pipeline vs. LNG
- Energy Turnaround
- Public Perception
- Qualification and Recruitment
- Facets for maximum Safety
- Cyber security
- Hot tapping
- New markets for pipelines/Eurasia etc

Topics of particular interest - such as pipeline safety in Germany - had been examined from various angles in compact sessions during the conference and, after further revision, published as a special edition of ptj. This system will be implemented more frequently in the future - e.g. for the side conference of the 14th ptc. I believe that this will provide our pipeline sector with compendiums that meet the same requirements as the **ptc seminars** - namely in their function as a reference book.

We have developed this system of **ptc-ptj-seminars** in close cooperation with the operators and the pipeline industry. Thanks are due to all those who have contributed - and the invitation to continue to do so in the future.

Kindly find additional information on our websites:

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

Yours,

> Dr. Klaus Ritter,
President EITEP Institut
Chairman ptc
Editior in Chef ptj

MARCH 2019 / ISSUE 2

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ptc 2019

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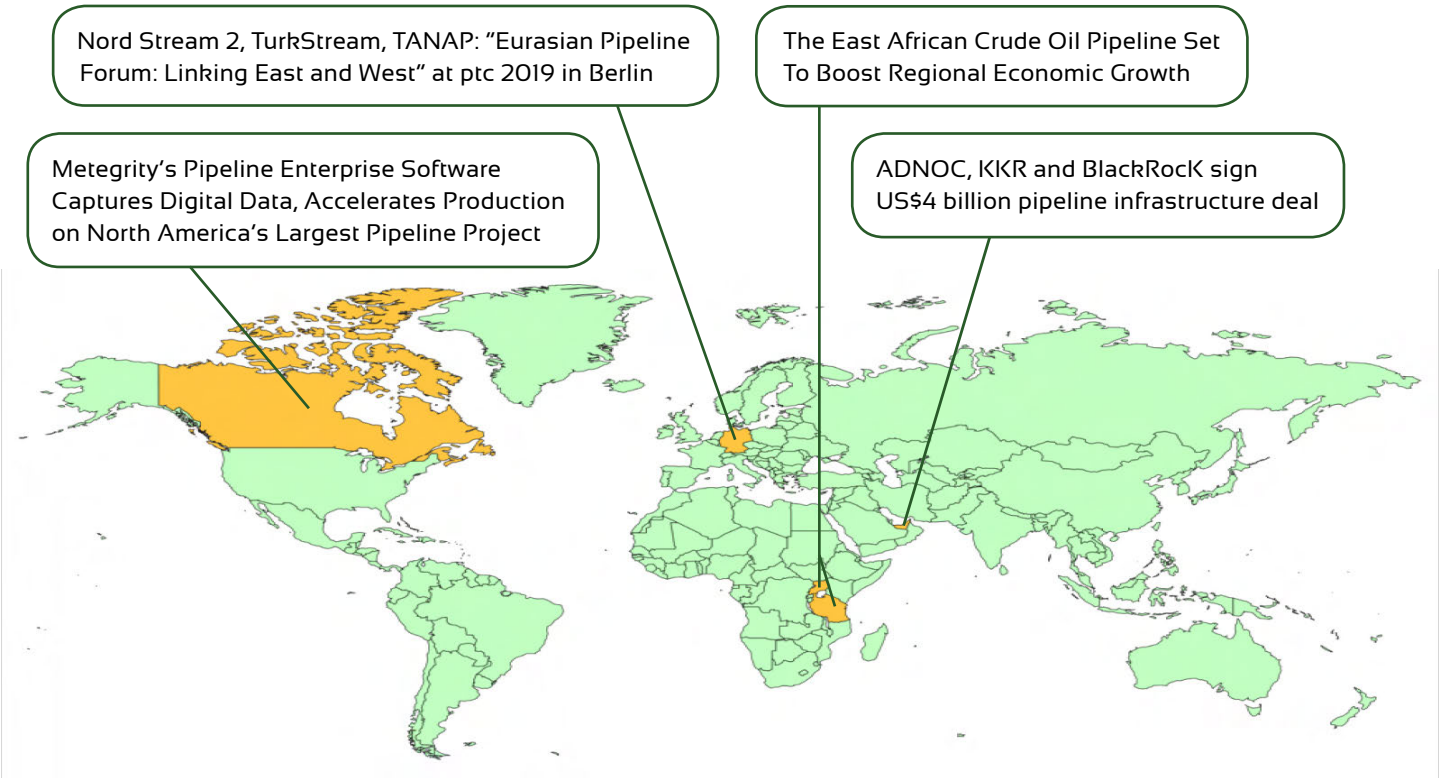

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ptc 2019 KEYNOTE

LEARNING FROM FAILURES: MOVING FROM 'FAILURE' CAUSE TO 'ROOT' CAUSE

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Abstract

This keynote presentation looks at the causes of engineering failures from many industries (aviation, construction, petro-chemical, medical, etc.). It suggests we can reduce failures in the pipeline industry by using the lessons learnt from these other industries, and emphasizes how the 'root' cause of a failure differs from the 'failure' cause. This differentiation is key to may full use of the lessons learnt.

1. INTRODUCTION

We all know that structures, such as bridges, pipelines, and ships, usually operate safely, but sometimes they fail. These structures fail due to a combination of:

- the load on the structure;
- any defect in the structure (a material or design defect will weaken the structure, or elevate stresses and accelerate failure);
- the properties of the materials that make up the structure (strength, shape, etc.);
- time the load operates (the longer a structure operates, the more likely it is to fail (for example, due to fatigue));
- the environment the structure operates in (e.g., temperature, corrosion, or irradiation, can - over time - weaken the material).

These are the engineering/technical causes of failure, but the reasons for the failure will be:

- design errors;
- faulty materials;
- construction errors;
- operating errors; or,
- human/management/organizational errors.

There are many publications on learning from 'engineering' causes of failure (i.e., the direct cause) such as poor design, or improper installation, but this presentation will show that these 'engineering' failures are actually caused by organizational failures (poor safety culture[1], organizational and management problems, lack of staff competence, etc.).

These are the 'root' (underlying) causes.

2. FAILURE CAUSES

Industries, such as the pipeline industry, publish failure data and list causes; for example, Figure 1 [1].

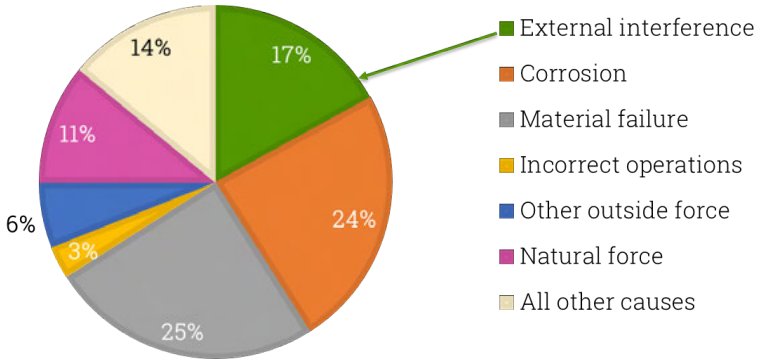

Figure 1: Failure causes in USA gas transmission pipelines, 1994 – 2013

These failure statistics are invaluable, and help track both performance and failure trends, but they do not give the cause of the corrosion, material failure, etc.. They are summaries, and limited to the engineering failure cause - the headline. Actual failure investigation reports do give far more detail, and do search for the underlying cause, but often avoid deeper investigation into this cause as it might be due to organizational problems, management mistakes, etc., which have legal implications, and would significantly extend the failure investigation. The underlying, or 'root', cause is often identified by subsequent legal processes.

3. ROOT CAUSES

Reports on structural failures usually describe the consequences, rather than causes of the incident. They explain what happened, but not why it happened, and are almost invariably technically-orientated [2].

The failure investigation needs to identify root causes; i.e., the reasons why an incident occurred. This allows organisations to learn from past failures and avoid similar incidents in the future [2]. We can consider the root cause of a failure as the factor(s) that when we fix it, the problem goes away and does not come back: we are not interested in the failure 'symptoms'.

Now, failure reports from many industries are reporting root causes and these are not simply reporting engineering causes; for example:

- The report on the tragic failure of the Deepwater Horizon drilling rig in 2010 noted [3]: *'The … loss of the Macondo Well could have been prevented. The immediate causes of the Macondo well blowout [are] systematic failures… that… place in doubt the safety culture of the entire industry…'*.
- The oil and gas industry is considered a 'major hazard' industry and it has been noted that these industries must be careful with 'change' [4]: *'Organisational changes… are usually not analysed and controlled as thoroughly as plant or process changes. Such changes can… have a detrimental effect on safety… changes to organisations can have significant impacts on the management of hazards.'*
- *'Investigation into a number of the recent disasters…led to the conclusion that the safety systems had broken down. This was not because of how safety was managed i.e. the policies and procedures in place, but because of the safety climate and safety culture of the organisation in which the safety management system was in place.'* [5].

- A gas pipeline failure in San Bruno, USA in 2010 killed 8 people, with costs of $2.8 billion (2015). A weld in the pipeline failed, but the root cause of the failure was… *'organizational failure'* [6].
- *'…accidents and incidents seldom arise from a single cause: there are usually underlying failures in the management system itself which have helped create the circumstances leading to the event.'* [7].

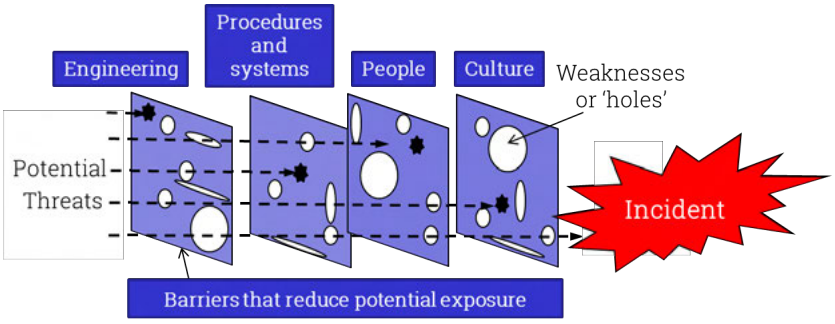

Figure 3: Failure occurs when all the faults in the barriers line-up

'Safety culture', 'management system', 'organizational failure', are being stated as the root cause of these failures. Contrast these root causes with the failure causes detailed in Figure 1.

4. SYSTEM FAILURE

A major conclusion from failure investigations is that a failure usually occurs when a 'system' breaks down, as most systems have multiple 'barriers' that prevent failure [8], Figure 2. Failure occurs when these barriers are breached, as no barrier is perfect. Failure occurs when these inevitable faults in the barriers line-up, Figure 2. This figure shows an example of a pipeline failing by corrosion:

- the coating and cathodic protection (CP) are faulty (and lead to corrosion); and,
- the inspection systems are faulty (and did not detect the corrosion prior to its failure).

Unfortunately, these faults have lined-up and there is a failure, Figure 2. This is a simplistic view of a failure, as it is only considering the engineering barriers and failures.

This ignores the systems supporting these engineering barriers: the people; management; organisation; and, corporate culture. A better view of these barriers, and one that accounts for the whole system, is to group them as (Figure 3):

- engineering barriers;
- systems barriers;
- people (competence) barriers;
- safety culture.

Using this wider description of barrier failure, we can revisit the corrosion failure in Figure 2, and reassess the failure causes; for example:

- the coating and CP fail… *engineering failure* cause;
- the inspection system failed… *engineering failure* cause;
- procedures in place did not detect there engineering failures… *systems failure*;
- staff did not see these system failures… *people failure*;
- management failed to check these system failures… *management/culture failure*.

This wider view allows us to identify root causes, rather than simply engineering causes. It also gives us all the areas we need to address/improve to prevent another similar failure.

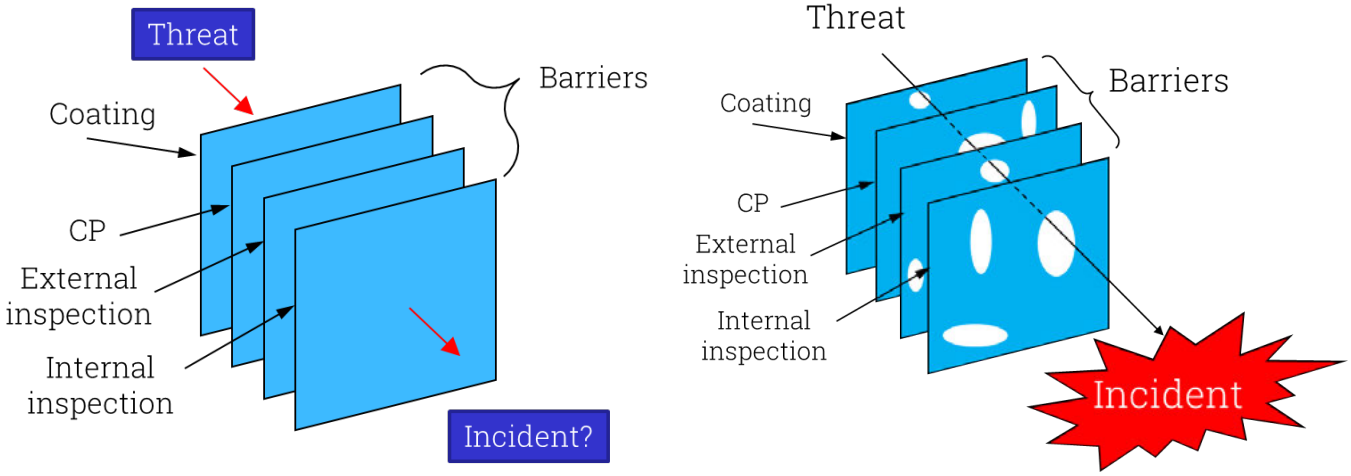

Figure 2: Failures are prevented by engineering barriers, but barriers are not perfect

5. SAFETY MANAGEMENT SYSTEMS

The pipeline industry now uses 'pipeline integrity management systems' (for example, References 9 to 12). Pipeline 'integrity management' seeks to understand and control both [13]:

- the probability of failure; and,
- the potential consequences of failure of a pipeline in a particular area along its route.

A 'management system' is [14]: *'A framework of processes and procedures used to ensure that an organization can fulfill all tasks required to achieve its objectives'*.

Most management systems are based on the continual improvement cycle of 'Plan, Do, Check, Act':

- Plan: plan the work to be done;
- Do: complete the work;
- Check: evaluate and monitor the work;
- Act: improve and integrate lessons learned.

Pipeline integrity management sets priorities for inspection and operations and maintenance based on whether people, property, or the environment might be at risk should a pipeline failure occur, rather than simply following an agreed inspection and maintenance plan. This is achieved by the pipeline integrity management systems identifying threats to a pipeline, Table 1 [15].

A management system helps us manage a particular aspect of our business, but having a safety or integrity management system in place does not guarantee success in managing safety or integrity. Identifying threats is only part of the process. The key to success is how the management system operates in practice, and this depends on [16, 17]:

- management leadership;
- ownership at all levels in the business;
- effective implementation;
- continuous improvement;
- assessment of hazard and risks;
- enhanced controls;
- communication and consultation processes;
- monitoring and review.

A failure can occur when any part of this system is faulty, and not simply the engineering parts of the system. The management system must be able to prevent failure, but if a failure occurs it must be able to give both the failure cause and its root cause.

External Corrosion.
Internal Corrosion.
Environmental Cracking (including stress corrosion cracking).
Structural/Material Degradation (non-steel pipe).
Manufacturing-related Defects (includes defective pipe and seam acted on by fatigue or other failure mechanisms).
Instruction-, Installation-, or Fabrication-related Defects (includes defective girth weld, fabrication weld, wrinkle bend or buckle, stripped threads, broken pipe, etc.).
Equipment Failure (includes failure of control/relief equipment, pump, compressor, seal/pump packing failure, etc.).
Excavation Damage (includes damage by operator, contractor, or third party).
Other Accidental Outside Force Damage (includes causes such as vehicles, other fire or explosion, electric arcing).
Intentional Damage / Vandalism / Sabotage.
Incorrect / Improper Operation (includes human errors).
Geohazards / Weather / Natural Force Damage.
Other / Uncategorized / Emerging Threat.

Table 1: Threats to a Pipeline

6. LEARNING FROM OTHER INDUSTRIES

The pipeline industry is very good at reporting failure causes (e.g., Figure 1), but it does not have the same data on root causes.

Other industries are reporting root causes of failures that are of interest to the pipeline industry, and they give an insight into what the pipeline industry may have to deal with in the future.

6.1. The aircraft industry

NASA and the Department of Transportation in the USA report human error as being responsible for 60% to 80% of aviation accidents [18, 19]. Data from Boeing support these data, and show how accident causes have changed in aviation history, Figure 4 [20].

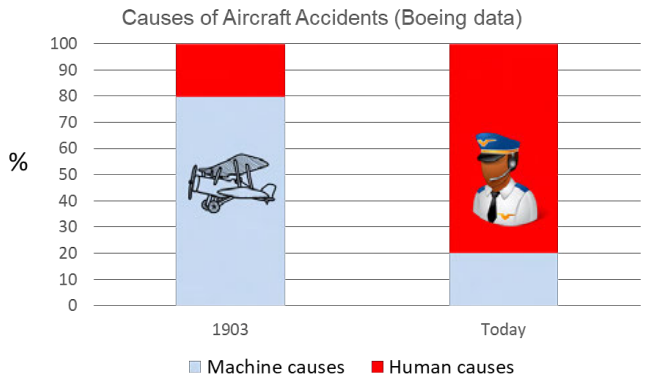

Figure 4: Causes of commercial aircraft accidents

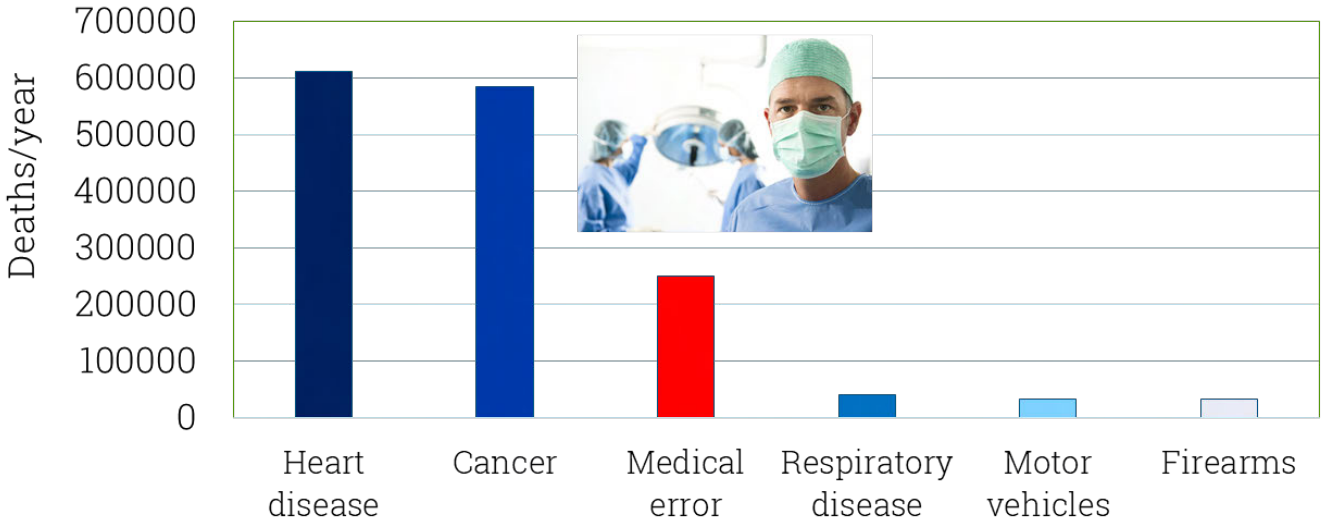

Figure 5: Major causes of death in USA (2013 data – John Hopkins University)

The same Boeing report emphasised culture, working environment, supervision, and personal character:

'A contributing factor [to air accidents] is anything that can affect how the maintenance technician or inspector does his or her job, including:

- *the technician's own characteristics;*
- *the immediate work environment;*
- *the type and manner of work supervision; and,*
- *the nature of the organization for which he or she works.'*

The aviation industry has seen huge improvements in safety due to [21]:

- technology;
- improvements in air traffic control; and,
- pilot training.

The industry uses competency-based training, and assessment is based on 'competency standards' [22].

6.2. Medical

We are seeing a rise in 'failures' due to human error in medicine. Figure 5 shows data from the USA and 'medical error' is now the third cause of death in USA [23].

This human error is not confined to the medical profession: *'It is estimated that up to 80% of accidents may be attributed, at least in part, to the actions or omissions of people'* [24].

6.3. Refineries

The Texas City Refinery Report blamed the culture of the organisation on the 2007 deadly failure [25]. Poor organisation was the number one cause of the disaster [26]: *'... managers and executives... were largely focussed on personal safety – such as slips, trips, falls, and vehicle accidents – rather than on improving process safety performance, which continued to deteriorate...'.*

Clearly, management should not focus much of their risk management effort on low consequence, high frequency events, (e.g., minor injuries caused by people tripping over), but need to put much more effort needs to be allocated to lower frequency, high consequence events (e.g., large releases of hazardous chemicals).

6.4. US Navy

'Near misses', or poor practices, should never be ignored. Data from the U.S. Navy show that the contributing factors to low-cost/no-injury events were the same contributing factors that caused high-cost/personal-injury events; therefore, addressing the contributing factors to lower-level events can prevent higher-level events [27].

6.5. Hazardous industries

A review of past major incidents in hazardous industries indicates that the lack of certain skills or knowledge has contributed to the incident. In each case, it had been assumed that an individual with a certain level of experience or training would be competent [28].

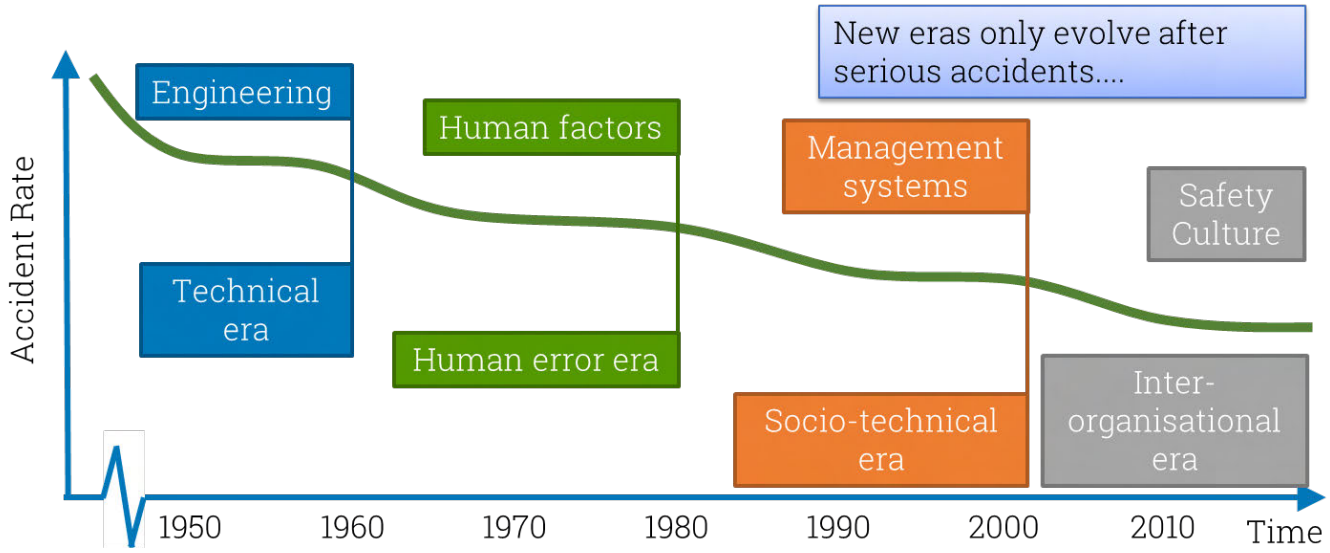

Figure 6: Changing causes of accidents in the chemical process industry

6.6. Nuclear industry

The nuclear industry emphasises the link between human performance and nuclear safety [29], and uses competency assessments for:

- employee selection;
- trainee assessment;
- qualification and requalification;
- job advancement and promotion; and,
- 'certification' or 'licensing'.

6.7. Chemical process industry

Data from the chemical process industry show how failure causes change with time. Early industry failures were caused by engineering errors (poor materials, poor construction, etc.), Figure 6 [30]. As the industry matures, and technology improves, the engineering failures will reduce. The most recent trends in failures are linked to safety culture, and relationships between contractual entities, and the problems that can bring.

6.8. Construction industry

'Design errors' can cause 80 to 90% of the failures occurring on buildings, bridges and other civil engineering structures, but design errors can be significantly reduced [31]:

- design checks can detect 32% of errors;
- independent third party verifications can prevent up to 55% of these design errors.

Reducing design errors is, obviously, important, but more important is a conclusion that these design errors have clear root causes [31]:

'Design errors are a symptom of dysfunctional organizational and managerial practices that prevail within the construction industry.... cost and time pressures appear to be prevailing nemeses contributing to errors and failures'.

6.9. Data management and corporate memory

It is worth noting that often we do not learn from past failures, and one of the reasons is data management [32]: *'The relevant information is almost always available: the problem is that it is either not known to the right people or its significance is not appreciated. Far from each failure or disaster being unique, there is usually a past history of similar events that could have resulted in failure but which for some reason didn't.'*

Industrial accidents occur because we do not use the knowledge that is available [33]: *'Organisations do not learn from the past or, rather, individuals learn but they leave the organisation, taking their knowledge with them, and the organisation as a whole forgets.'*

7. SUMMARY

We know the failure causes of pipelines; e.g., Figure 1. These are valuable data, but give little guidance on how to prevent them in future. Similarly, pipeline integrity manage-

Figure 7: Reducing failures and root causes

ment systems focussed only on the (engineering) threats to a pipeline (Table 1) will miss key barriers (and deficiencies) in the integrity management system (Figure 3).

Other industries are looking closely at safety culture, organisational structure, competence, knowledge/data management, etc., to reduce future failures, and their experiences can be used by the pipeline industry.

We prevent pipeline failures by having effective pipeline integrity management systems [34], but we can do more, and experience in other industries show us how to reduce failures further, by broadening the pipeline integrity management system considerations (Figure 3), and determining the true/root cause of failure, and not simply the failure cause, Figure 7.

These root causes could be grouped into:

- safety culture (e.g., staff put safety second);
- staff/corporate competency (e.g., incompetent staff);
- data management (e.g., incorrect or insufficient data);
- knowledge management (e.g., loss of experienced staff);
- organisational error (e.g., contracting error);system error (e.g., errors in procedures);
- system error (e.g., errors in procedures);
- human error (e.g., poor judgement);
- near miss (e.g., low consequence event ignored);
- malicious act (e.g., theft).

Footnotes

1 'Safety culture' is part of the overall culture of an organisation and reflects the collective attitudes and values which the operator's employees share with respect to risk and safety.

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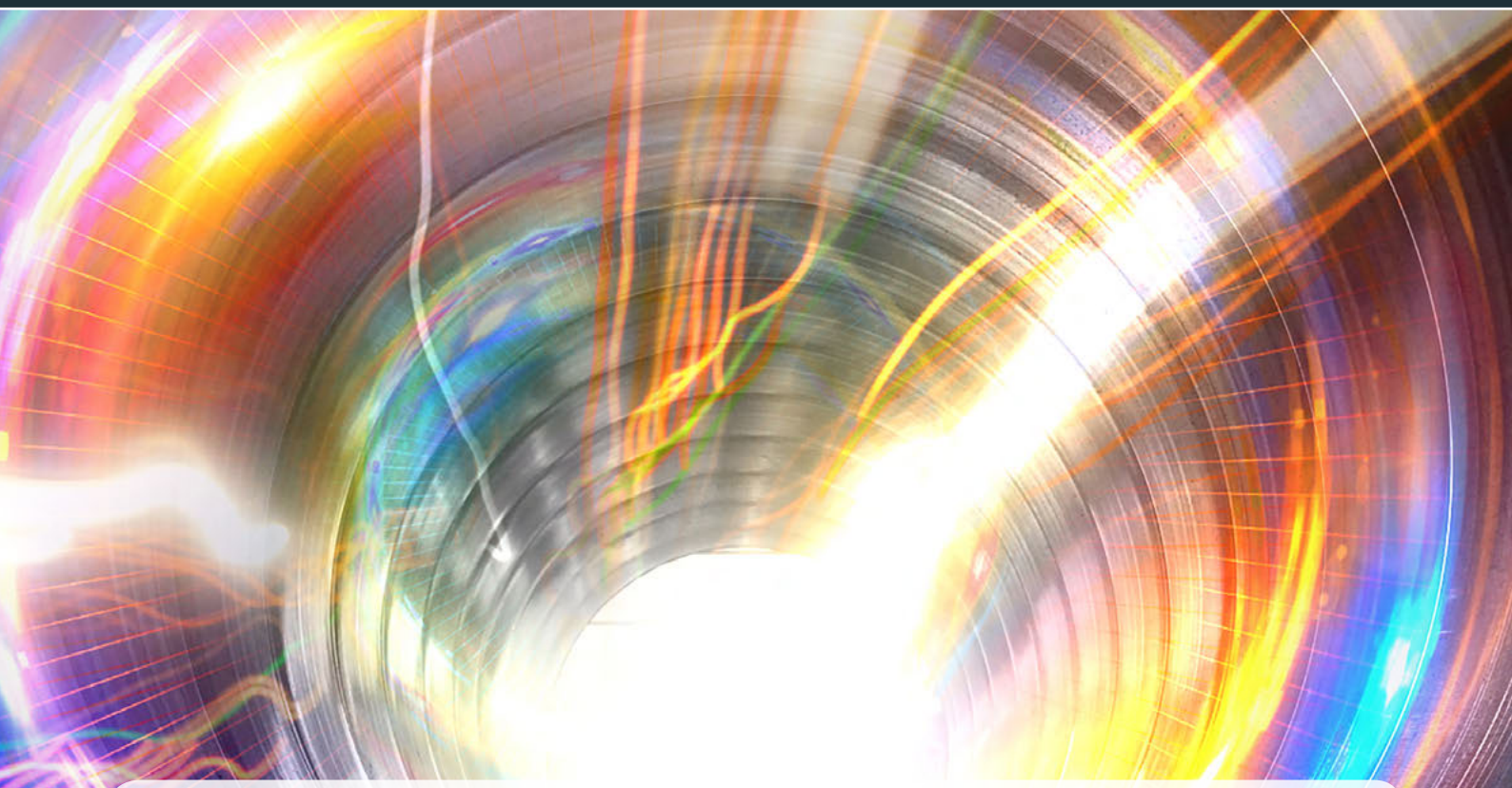

Abstract

This paper discusses pipeline internal deposition mapping and the benefits to operators of end-to-end pipeline internal diameter mapping, the practical application of this unique, nonintrusive technology, and insight about the full technical reach of this diagnostic service.

A pulse of pressure is induced in a pipeline by using the operation of a fast-acting valve closure in the flowing line or by the rapid opening and closing of a bleed valve on a blocked line. The valve closure creates a pulse (similar to a fluid hammer effect) that travels through the medium in the pipeline at the speed of sound. The magnitude of the pulse and the pressure response of the pipeline from the induced pressure pulse as it travels along the pipeline are measured using a high-fidelity, ultra-high resolution pressure transducer and data logger. After processing the data using proprietary algorithms and software, the deposit profile is "mapped."

A major benefit of the system is that the survey can be used on live pipelines with little or no production disruption. Analysis requires one day under ideal conditions for a preliminary report and a week for final reporting, subject to the particular line parameters at the time of the survey.

For a debris-profiling survey performed in ideal pipeline conditions, the depth of deposit can be identified to an accuracy of 1 mm and the location of the deposit within the pipeline to within 100 m. When performing a blockage location survey, the location of a blockage can be detected to within 0.4% of pipeline length and can be performed on rigid, flexible, liquid-filled, or gas-filled pipelines, subject to a feasibility assessment.

1.0 INTRODUCTION

Pipelines that have been in operation for a period of time may experience a buildup of deposits along the line that restricts flow. In addition to loss of functionality, this buildup can also increase the risk of a stuck pig or the formation of a complete blockage. Figure 1 shows types of deposit that can accumulate in the line.

Internal deposition mapping by means of an induced pressure pulse survey is a non-intrusive method that can measure the flow area along the full length of a pipeline. This method provides operators with a greater depth of information, as compared to a 'Time of Flight' survey method, because deposition is not only volumetrically quantified, but a granular picture of deposition placement is also created. The technique provides additional advantages because the completion of the survey is simple and, at 30 seconds in length, very fast. A survey does not require equipment and/or sensors to be flown/driven along the immediate vicinity of the length of the pipeline. Consequently, for example, vessels and/or ROVs are not required for subsea pipelines as long as there is a topsides connection for the data logger.

The survey results in dynamic (still flowing) conditions provide valuable information about the hydraulic diameter along the entire length of line to identify areas where debris is restricting throughput. Depending on the application, this information enables informed decision-making, whether it is to improve the efficiency of a cleaning program, or to mitigate risks regarding the use of a pig or an alternative cleaning method. Pipelines that are fully blocked as a result of debris or foreign objects cause significant production loss, and locating blockages can be a time-consuming process. Conducting a survey significantly reduces the amount of time required to precisely locate the blockage and provides information to help rapidly determine the best course of action and entry point for remediation.

2.0 PRACTICAL APPLICATION OF AN INDUCED PRESSURE PULSE SURVEY

2.1 Pipeline Conditions

The ideal pipeline conditions for performing a survey include the following:

- Homogeneous and single phase fluid
- Steady flow (debris profiling survey)
- Steady pressure (blockage location survey)
- Quick action valve to generate the pulse.
- Tie-in point for pressure transducer between the pulse generation valve and the system being surveyed

Surveys can still be performed, however, even if the pipeline is not in ideal condition, provided that the parameters remain within the following tolerances:

Phase: <5% gas in liquid or liquid in gas to maintain reasonable accuracy. Up to 20% can be performed; however, accuracy will begin to be affected.

Flow Rate: The lower the flow rate, the better the sensitivity of the results. This consideration is particularly important with heavily deposited line as a result of higher friction. A lower flow rate increases the relative noise level (for example, weather, platform movement, pressure fluctuations from the other end of the pipe, and flow instability in flow before the valve closure). The flow rate must also be high enough to produce a suitable fluid hammer, but low enough to maintain the fluid hammer at a safe level. Flow fluctuations during the survey must be minimized because they will not be distinguishable from debris reflexes during analysis.

Pressure: Must be high enough to produce a suitable fluid hammer, but low enough to maintain the fluid hammer at a safe level in each section. Pressure fluctuations during the survey must be minimized because they may interfere with the identification of the blockage reflex during analysis.

Paraffin Wax

Scale

Hydrate

Figure 1: Types of deposits that can accumulate in the line

"A major benefit of the system is that the pressure pulse survey can be used on live pipelines with little or no production disruption.

Keith Drummond

Valve: Hydraulically actuated ball valves, which can close consistently and as quickly as possible, are used for the debris survey; quarter turn bleed valve, which is rapidly opened and closed, is used to determine blockage location.

Transducer: The pressure transducer must be located within approximately 100 m of the pulse generation valve on the pipeline side.

2.2 Generating a Pulse

The pulse used for the survey is generated by creating a fluid hammer in the pipeline. There are several ways of accomplishing this, depending on the type of survey required. The following subsections describe specific required conditions; Figure 2 and Figure 3 illustrate a typical rig-up layout.

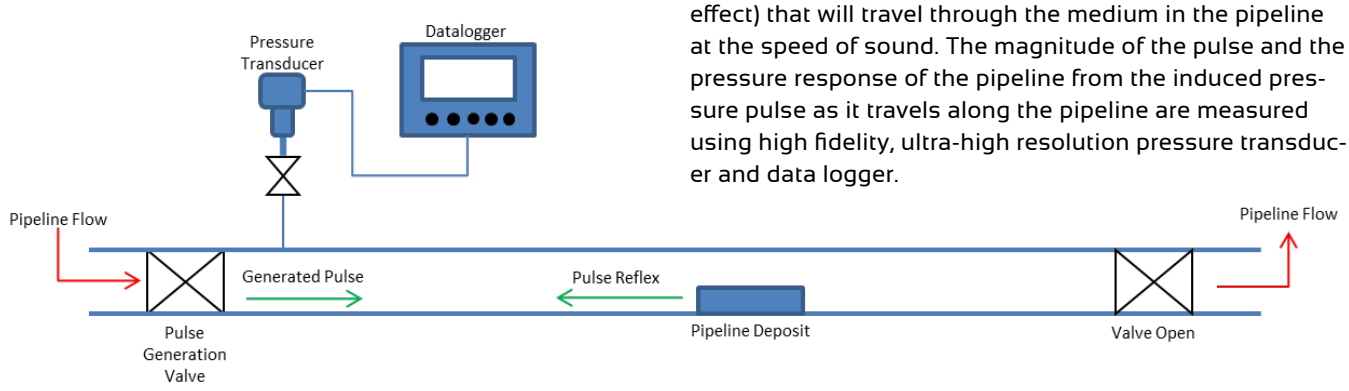

Figure 2: Debris profiling rig-up

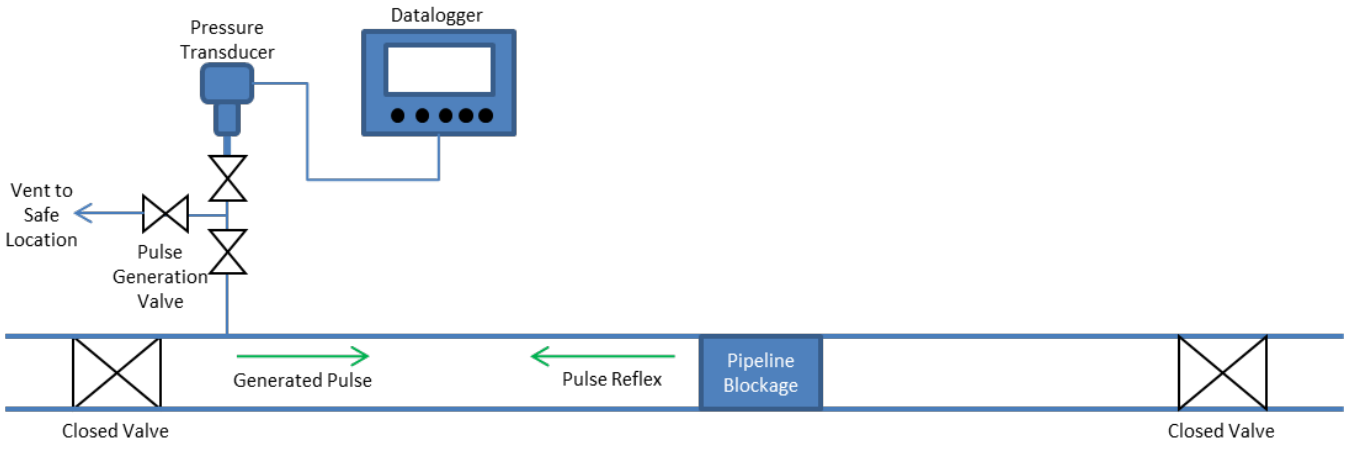

Figure 3: Blockage location rig-up

2.2.1 Debris Profiling

To generate a pulse suitable for a debris profiling survey, the pipeline must be in a state of stable flow. A quick closure valve on the main pipeline is closed to generate a pressure wave; this valve is maintained in the closed position for the duration of the survey. Hydraulically actuated ball valves provide an ideal situation because they can close consistently and as quickly as possible.

2.2.2 Blockage Location

To generate a pulse suitable for a blockage location survey, the pipeline being surveyed should be under pressure to provide the energy for the pulse generation. In addition, a mechanism must be in place to enable the generation of a pressure pulse by quickly bleeding a small volume from the pipeline; this is usually accomplished by the rapid opening and closing of a quarter turn bleed valve, as shown in Figure 3.

2.3 Data Acquisition

The valve closure creates a pulse (similar to a fluid hammer effect) that will travel through the medium in the pipeline at the speed of sound. The magnitude of the pulse and the pressure response of the pipeline from the induced pressure pulse as it travels along the pipeline are measured using high fidelity, ultra-high resolution pressure transducer and data logger.

An ultra-high-rate data logger (Figure 4) sampling at 4000 Hz is used to collect the data. This arrangement provides the equivalent of collecting a data point every 20 cm in a water-filled pipeline. This process ensures that the recording of the reflected pulse is rich with data.

The equipment is contained in a small case (54 cm (l), 36 cm (w), 22 cm (h)) that weighs 14 kg. A standard unit consists of a data logger, a set of pressure transducers with different pressure ranges, cables, and chargers (Figure 5). The equipment is ATEX Zone 2 compliant and contains a 65 Wh lithium-ion battery.

During operation, the pressure transducer is located near the valve that will be used to induce the pulse of pressure. It can be situated at either the inlet or the outlet end of the pipeline. The reflections or pipe response from the pulse as it passes through the pipeline are processed to provide the profile and thickness of deposits and, subsequently, the available flow area along the pipe. The profile of the induced pressure pulse at the upstream end of the pipeline will be a negative pulse; alternatively, for a pulse generated at the downstream end of the pipeline, the profile will be inversed and provides a positive pulse. The data collected with either a positive or negative pressure pulse are essentially the same.

A major benefit of the system is that the pressure pulse survey can be used on live pipelines with little or no production disruption. Analysis requires one day under ideal conditions for a preliminary report, and a week for final reporting, subject to the particular line parameters at the time of survey.

For a debris profiling survey, performed in ideal pipeline conditions, the depth of deposit can be identified to an accuracy of 1 mm and the location of the deposit within the pipeline to within 100 m. When performing a blockage location survey, the location of a blockage can be detected to within 0.4%.

Initially developed with liquid-filled rigid pipelines, the algorithms and analyses have been extended to now enable the service to be run in gas-filled pipelines, with flexible pipelines also to be considered. Ultimately, each pipeline is considered on an individual basis to determine its feasibility for conducting a pressure pulse survey.

Pipeline internal diameter (mm)	Pipeline features (if any)
Pipeline wall thickness (mm)	Product phase
Pipe material Young's modulus (Pa)	Flow rate (kg/s)
Pipeline length (m)	Pipeline pressure gradient (barg)
Friction factor	Pipeline temperature gradient (deg. C)
Material type	Fluid density (kg/m^3)
Deposit composition/distribution	Fluid bulk modulus (Pa)
Pipeline topography	Fluid viscosity (cP)

Table 1: Information required for data analysis

Figure 4: Ultra-high-rate data logger

Figure 5: Data-logger transducers, cables, and chargers in a case

2.4 Data Analysis

After receiving the data from the site, a preliminary report that includes details about the initial survey results will be issued to the operator within 24 hours. A detailed final report presenting the survey results will be issued to the operator within five working days of the receipt of the data.

2.4.1 Operating Conditions

For data analysis, it is crucial that the necessary information be provided as accurately as possible; it should also be adjusted to operating conditions at the time of survey. Table 1 lists the information needed for data analysis; the factors in shown in red must be adjusted to operating conditions.

Inaccuracies in any of the operating information provided will affect the accuracy of the pressure pulse survey analysis, and therefore will reduce the accuracy of the results.

A review of the piping and instrumentation diagram (P&ID), system, fluid, and process conditions will determine the suitability of each system for pressure pulse survey. This review will determine the appropriate valve closure and strength of the required pulse to be generated because these factors are application-specific and

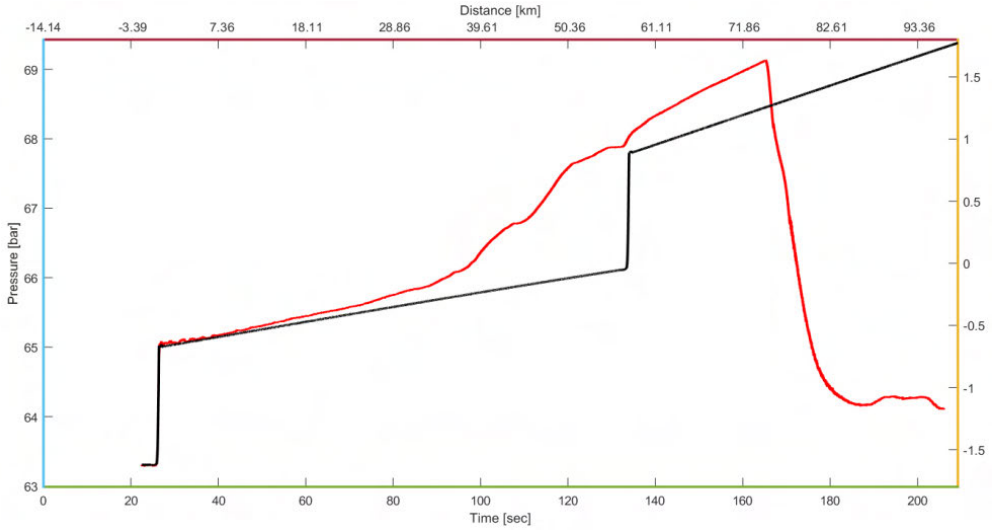

Figure 6: Pressure pulse survey raw data

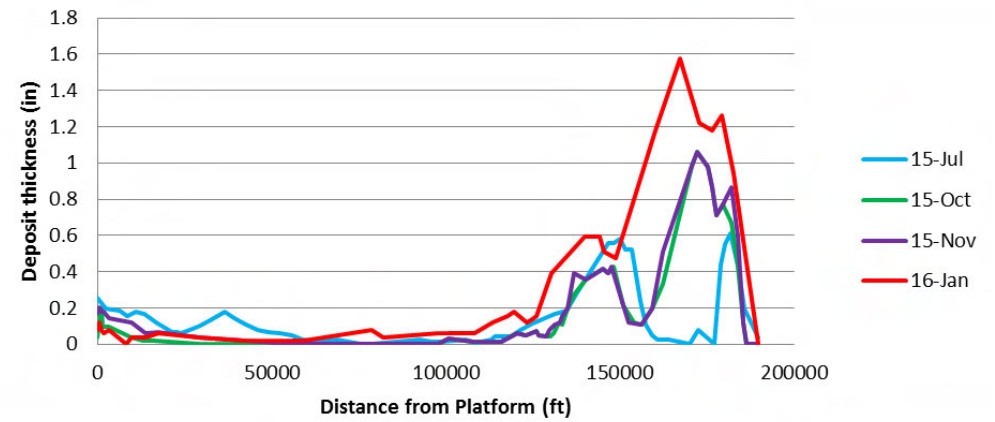

Figure 7: Deposit thickness

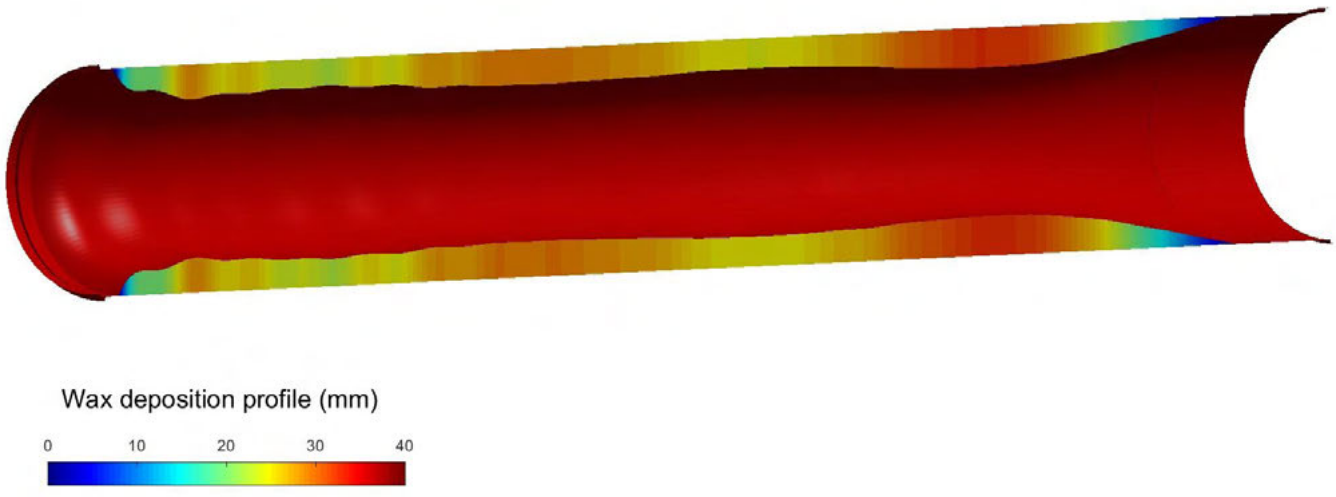

Figure 8: 3D profile of deposition

considered on a case-by-case basis. The temperature, density, and viscosity of the fluid and a stabilized known flow rate at the time of the survey are required to produce accurate results.

2.4.2 Pressure Pulse Survey Graph Examples

Figure 6 provides a plot of the raw data that shows the recorded pressure vs time. The measured response (red) is compared to expected response from a clean pipe model (black).

After processing the data by means of proprietary algorithms and software, the deposit profile is assessed.

Figure 7 illustrates the deposit thickness in inches at a distance in feet from the inlet. In this example, multiple mapping surveys (blue, green, and red) were performed over several months and shows a change in paraffin wax deposits over time.

Figure 8 provides another representation of the deposit profile along the pipeline.

3.0 USES FOR THE SURVEY/ EXAMPLE CASE HISTORIES

This section describes potential uses for the induced pressure pulse survey and provides case history examples.

3.1 Uses

Induced pressure pulse surveying has several potential uses. These uses include, but are not limited to, the following:

- Stuck pig location/full blockage location
- Restriction location and quantification
- Valve position verification
- Defect detection and location
- Effectiveness analysis of cleaning campaign
- Effectiveness analysis of blockage/restriction prevention treatment
- Pre-pigging analysis on unpigged or infrequently pigged pipelines

Compounded by the relatively simple performance of a survey, the quickness of the survey, the mobility of the minimal equipment, and the high benefit-to-cost ratio, induced pressure pulse surveys provide operators with effective data from which to derive valuable insight into their internal pipeline conditions.

3.2 Case Histories

This section includes three case histories, and describes the use and benefit of the survey performance in North America, the North Sea, and Thailand.

3.2.1 Case History 1: Stuck Intelligent Tool in North America

The operator had a stuck pig in an essential onshore export pipeline. There was an urgent need to locate this stuck pig using non-intrusive technology to prepare the most appropriate remedial solution at a refinery.

Consequently, it was decided to locate the intelligent pig stuck in the pipeline using the pressure pulse service.

Because very high accuracy and precision were required, a calibration survey was performed in a secondary system filled with the identical fluid before the pig location survey was performed. Three data sets were collected from the secondary system to calibrate the acoustic velocity of the supercritical ethylene medium using the known unobstructed distance of 30,438 ft between the tie-in connection and the upstream mainline valve. The three datasets had a similar profile with a clear initial pulse and reflex, which corresponds to the pulse travelling from the initiation valve, reflecting from the closed mainline valve, and returning to the origin point and the data logger. Using the known distance of 30,438 ft in conjunction with the average time of flight, the average acoustic velocity of the product medium under these particular system conditions was determined as 417.8 m/s.

Surveys were then performed in the system with the stuck pig and a very similar profile to the calibration survey. A clear indication of pulse initiation and reflex from the pig was observed during each of the pig location surveys, as shown in Figure 9.

From the data collected, the analysis results indicated that the pig was located 772 ft from the 'survey tie-in point'. After recovery, physical measurements from the caliper pig recorder confirmed that the tool had stopped at 763 ft, a difference of 9 ft from the stuck pig location predicted by the survey.

3.2.2 Case History 2: Wax Deposits and Stuck Pig in North Sea

A pipeline cleaning campaign was to be performed by pigging an 8-in., 58 km condensate pipeline between two offshore platforms. Before initiating the pigging campaign,

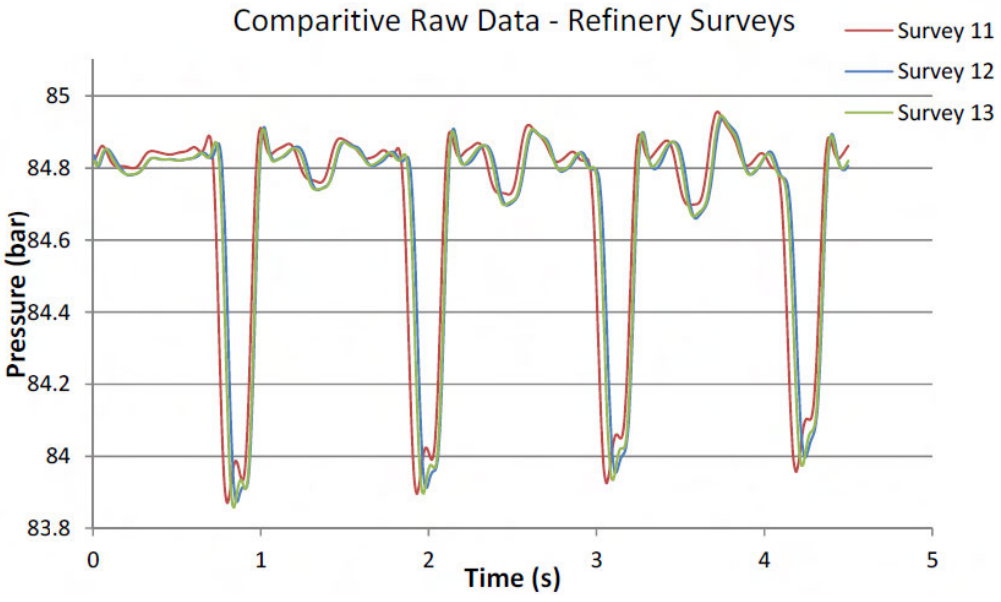

Figure 9: Pig location surveys

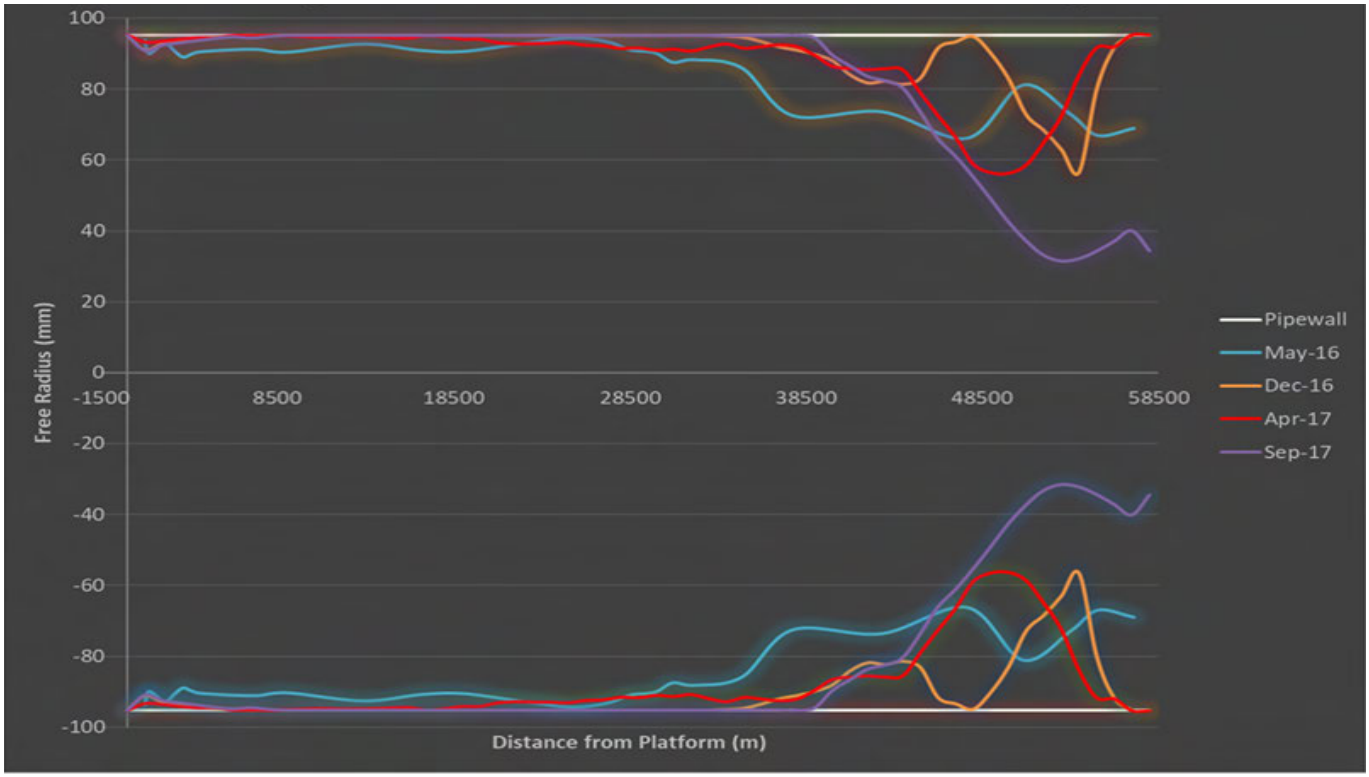

Figure 10: Two-month differential in deposit profile

a baseline assessment of the debris profile using the pressure pulse service was performed; it was determined that the deposit in the line had increased since the previous survey performed two months earlier (Figure 10). The pre-existing and increase in deposit was heavily focused between 40 and 58 km from the location of the pipeline survey.

On the fifth pig run of the cleaning campaign, approximately 70 to 140 minutes after launching the pig, flow was lost, and the pig became stuck. Using the recorded flow volume (71 m^3) and approximate time at when the line stopped flowing (70 to 140 minutes), the blockage was approximately 2906 to 5813 m from the point at which the pig was launched. The blockage location was surveyed by the pressure pulse service three times in a month from the receiving end of the pipeline in static conditions to locate the downstream end of the blockage. At the end of the month, the subsea non-return valve at the launching end was successfully latched open, enabling three additional surveys to be performed in static mode to locate the beginning of the blockage.

After reviewing all data collected, the total known blockage length was found to be 2881 m (52,851 to 55,732 m) and a conservative blockage length, taking into account any uncertainty resulting from fluid properties at the time of the survey, was 3843 m (52,122 to 55,965 m) as shown in Figure 11.

3.2.3 Case History 3: Lost Pig in a Flowing Pipeline in Thailand

A bidirectional pig was launched into a 16-in. crude oil pipeline from an offshore platform for receipt at another offshore platform located approximately 11 km away. After the expected receipt time passed with no indication of pig receipt, and although flow continued with no significant decrease or pressure increase, it was recognized that the pig was lost within the pipeline. It was decided to perform a survey using the pressure pulse service to locate the lost pig. Before conducting of the survey, a wye piece, located 2233 m from the pig launcher, was identified as the most likely position for the pig to have become stuck because no other significant pipeline features existed outside of the topside pipework (Figure 12).

Based on the line details and the crude oil physical properties, an acoustic velocity of 1108 m/s was calculated for the pipeline.

As shown in Figure 13, the closing sequence was fairly noisy because of the manual closing of the valve. The

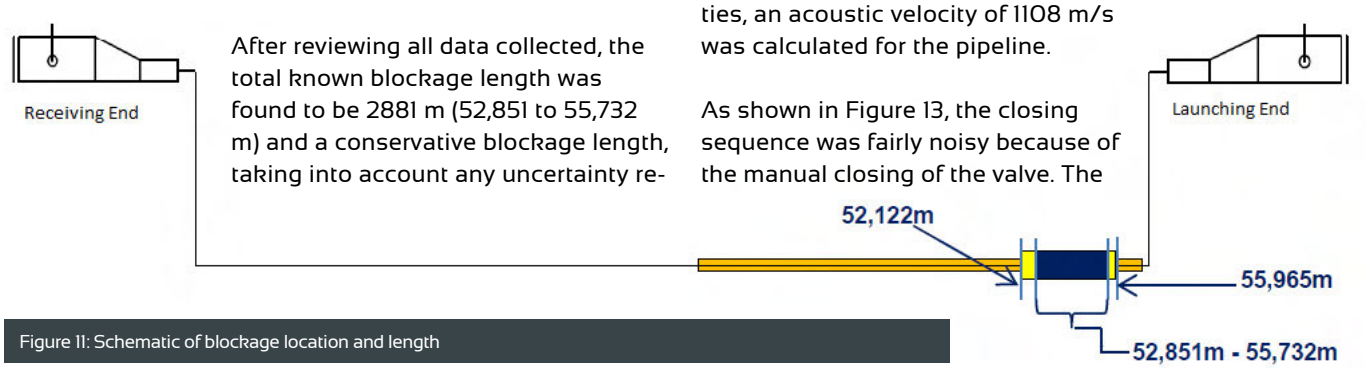

Figure 11: Schematic of blockage location and length

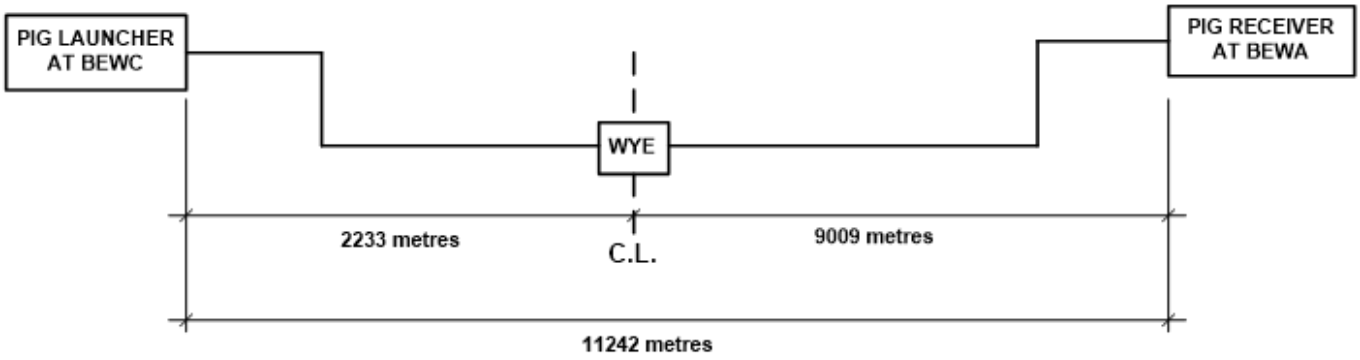

Figure 12: Overview of pipeline features

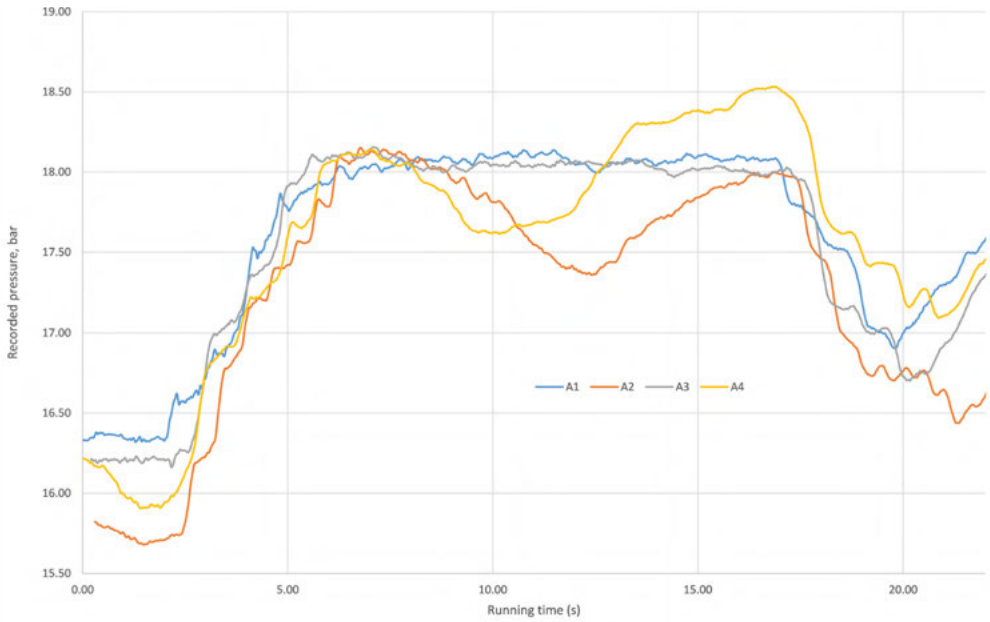

Figure 13: Data sets A1 to A3 from inlet of pipeline, A4 from outlet of pipeline

recorded pressure buildup time is approximately four seconds for each data set. Two of the data sets are fairly stable (A1 and A3), but the other two are dominated by noise resulting from surges in flow. Despite this noise, all signals provided a clear tool response, with high reproducibility between the data sets. All data sets show a large reflex after approximately 17 seconds, indicating the moment the pulse reached the blockage. After an additional survey from the outlet end of the pipeline, the analysis of the data collected indicated that the pig was located 2280 m from the survey tie-in point at the pig receiving facilities. This meant the blockage was located within 0.4% of the likely stuck position at the wye piece; this was an acceptable error factor to validate that the pig was located within the wye piece.

4.0 CONCLUSION

The pressure pulse method of surveying for deposit profiling and blockage location provides operators with fast, accurate, unique, and valuable data. With little to no interruption to production, this technique uses a simple non-intrusive means to gather data. Advanced, proprietary algorithms convert data into a tangible and usable format, providing greater depth to operational decision making, at a low cost.

Acknowledgements

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PIPELINE VIBRATIONS – MEASUREMENTS UNDER DIFFICULT CONDITIONS

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Abstract

In many technical applications pipelines are used for the transport of potentially flammable or hazardous gases and liquids. Vibration problems at pipelines often depend on the volume flow. Vortex shedding is a typical result of flow induced pulsations and may cause severe piping vibrations and failures. Another excitation source for critical pulsations or elevated vibrations is the use of compressors or pumps due to their unsteady working principle.

Measurements of pulsations and pipeline vibrations are important for the assessment of dynamic material loadings. In addition they often allow a comprehensive root cause analysis in case of elevated vibrations. In some cases it is not possible to install standard measurement equipment at the area of concern. Then special measurement technics and investigation methods have to be used. These different methods are presented in the following two case studies.

The first case study deals with a flow induced vibration problem at a grid gas manifold. Obvious vibrations occurred randomly during high volume flow in winter time. A long-term measurement was performed to determine the characteristic behavior. Spectral analysis and volume flow correlations enabled a precise characterization of the critical vibration phenomenon. On this basis a simple well working mitigation measure was identified and realized.

In another case elevated vibrations occurred in the reactor bay of a chemical plant, where a hyper compressor is used to compress ethylene with a discharge pressure of up to 3,000 bars. It was impossible to install extensive measurement equipment during compressor operation due to the hazardous conditions inside of the reactor. Therefore, a laser vibrometer was used to detect piping and steel construction vibrations from outside of the bay with distances above 100 m. A multitude of measurement positions allowed the detailed analysis of the vibration phenomenon. Finally, a measure was derived to improve the vibration behavior.

FIRST CASE STUDY – FLOW INDUCED VIBRATIONS AT A GRID GAS MANIFOLD

Elevated piping vibrations and additional ground borne vibrations were recognized at a grid gas manifold. Several residential houses are located next to the station. In the nearest house the vibrations were very extensive on the first floor.

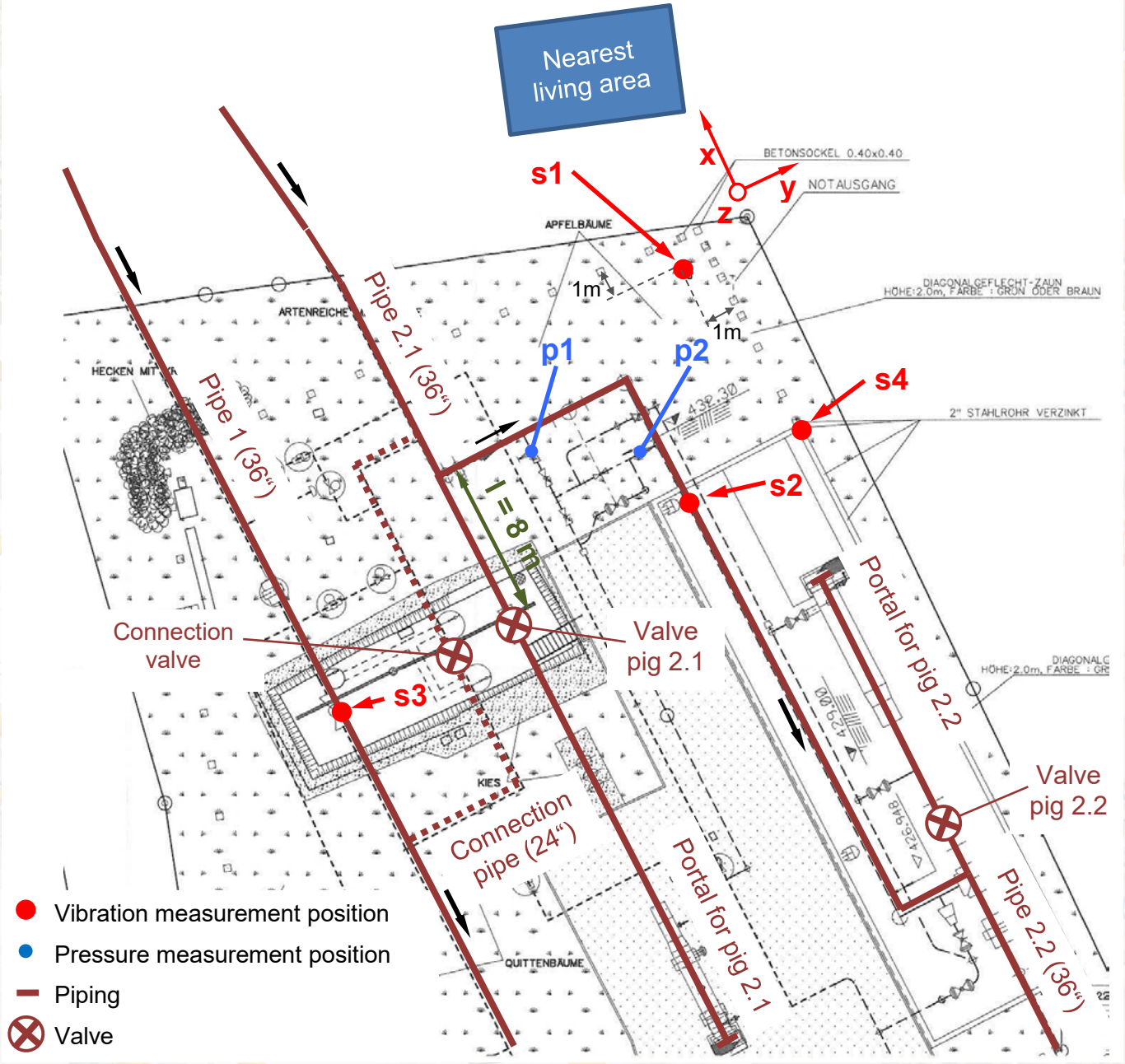

Figure 1: Overview map of the manifold with the used measurement positions for vibration sensors and pressure transmitters

A first assumption was that there is a correlation between the vibrations and the sometimes frozen ground. The vibrations also seemed to depend on the volume flow.

The piping up- and downstream of the manifold has been designed for 3,000,000 Nm³/h. The gas pressure is between 40 and 70 bars. Figure 1 shows a scheme of the manifold with the positions of the portals for pigs and a ground borne vibration sensible house next to the manifold.

The grid gas pipes (pipe 1 and pipe 2.1 / pipe 2.2) have a nominal diameter of 36". The connection pipe between them with the integrated valve has a nominal diameter of 24". This connection enables a consistent distribution of the gas flow between the two pipings. The manifold is also designed to place pigs inside of the pipings 2.1 and 2.2. Therefore, two additional valves (valve pig 2.1 and valve pig 2.2) are needed for separating the portals from the grid gas piping. The length of l = 8 m shown in figure 1 is important for the later root cause analysis.

To investigate the root cause for these vibrations, a long-term measurement was installed at the manifold. The used measurement configuration consisted of 4 vibration measurement positions with each 3 directions and 2 measurement positions for pressure transmitters (see figure 1). Two vibration measurement points were located directly on the piping and two others on the ground next to the nearest house.

Figure 2 shows the trendline of the volume flow during the long-term measurement.

The volume flow was always between 1,800,000 Nm³/h and 2,600,000 Nm³/h. Only for a short period the volume flow decreased below 1,000,000 Nm³/h during a shut down of the upstream compressor station. The also visualized effective vibration velocities and the effective pulsations alternated during the measurement campaign. The measurement positions s1 and s4 were chosen to document the ground borne vibration that may affect the people in the surrounding houses. The shown pulsation level in the giant piping with a diameter of 36" represents the dynamic excitation based on possible flow phenomena and the acoustic behavior.

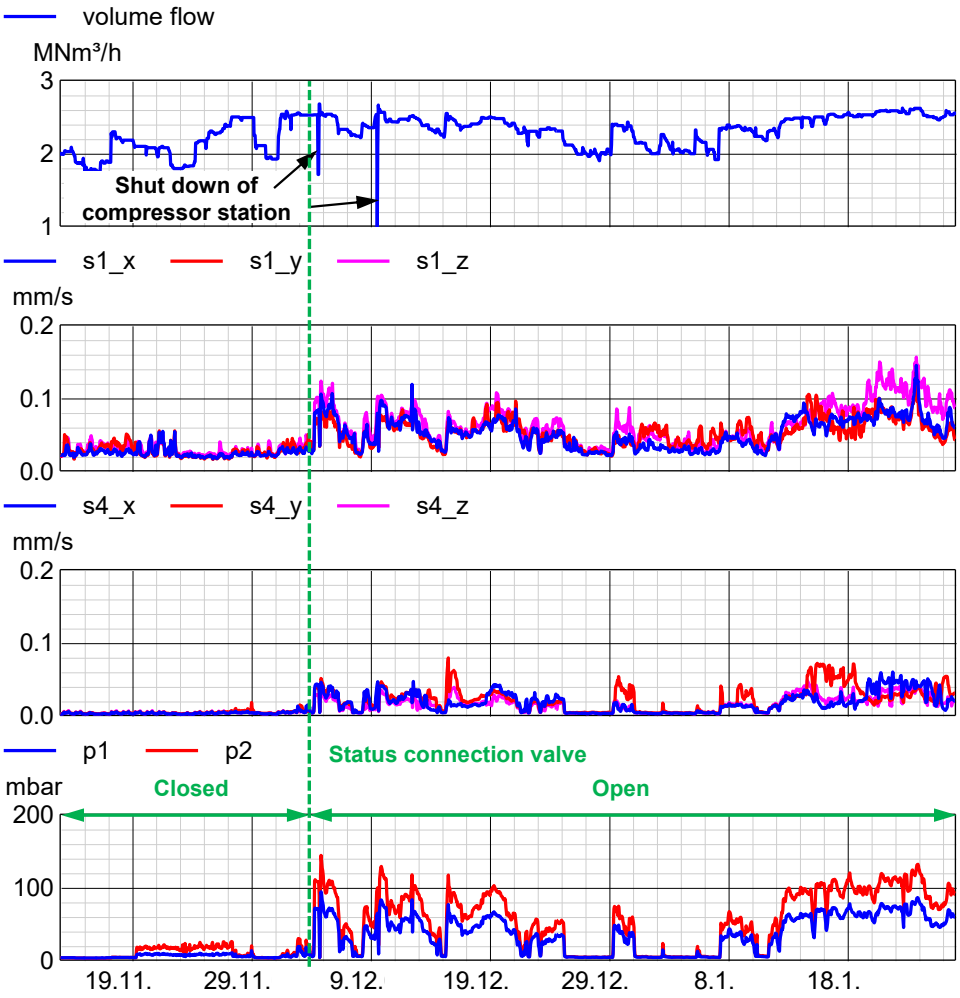

Figure 2: Trendline of volume flow, effective vibration velocities and effective pulsations during the long-term measurement (averaged values for one hour)

During this long-term measurement the connection valve was closed on 4 December. This seemed to have a massive effect on the pulsation and vibration situation at the manifold. From that moment on the pulsation and vibration level increased in dependency of the volume flow.

To obtain further information about the influence of the volume flow, the effective pulsation level is displayed above the volume flow in figure 3. This diagram shows a characteristic behavior of the pulsations inside of pipe 2. When the connection valve was closed, the pulsation level was almost below 25 mbar RMS. But when the connection valve was opened, the pulsation level increased with the growing volume flow – starting at about 2,200,000 Nm³/h. The maximum of 130 mbar RMS was reached at the maximum measured volume flow at the manifold. Possibly higher volume flows (up to 3,000,000 Nm³/h) could have led to a further increasing pulsation level.

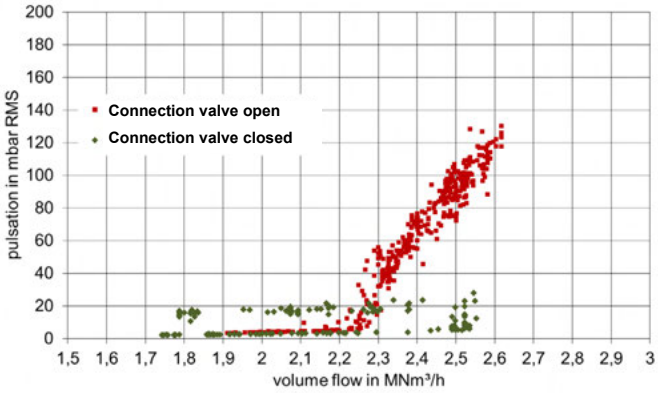

Figure 3: Dependency of the pulsation level at p1 from the volume flow for the open and closed connection valve

The dependency from the volume flow was also observed for the vibration level at the different measurement posi-

tions in a proportional way (without figure). Thus, it could be concluded that the appearance of the pulsations led to the recognized undesired vibrations.

In a next step the root cause for this pulsation excitation had to be found. For the time after the opening of the connection valve a spectral analysis was carried out. Figure 4 shows the spectra in a time plot. The intensity of each frequency is plotted by a color scheme.

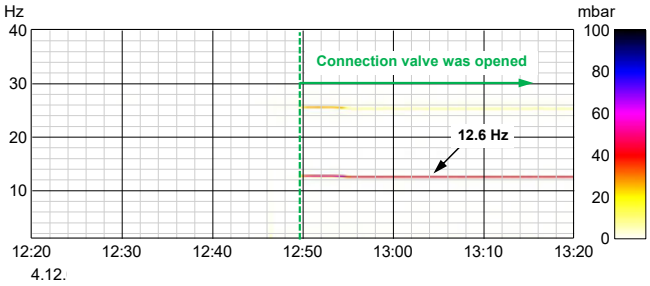

Figure 4: Chronological spectra of the pulsation at measurement point p1 as a color plot

A dominant frequency peak at 12.6 Hz occurred from that moment on when the connection valve was opened. The change in the flow behavior seemed to have a distinct influence on the acoustic in the piping. But this frequency appeared nearly independently from the total volume flow. In figure 5 two typical causes for the excitation and attenuation of such pulsations are displayed.

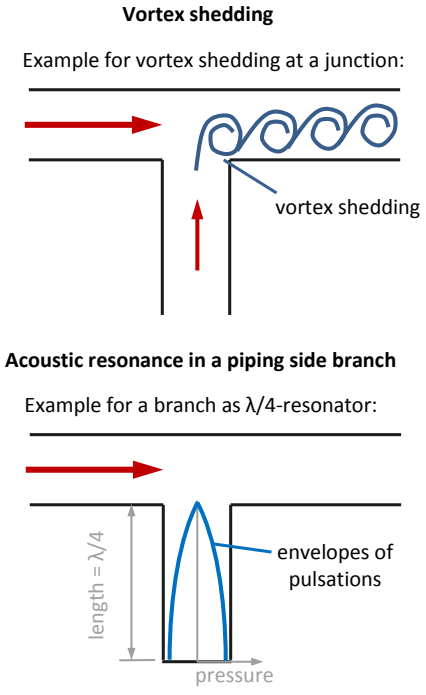

Figure 5: Typical causes for the excitation and attenuation of pulsations, top: vortex shedding, below: acoustic resonance

"The continuous flow of oil or gas through a pipeline seems to have a very stationary behaviour at first glance. In fact, many different physical effects can lead to pulsation and vibration problems. This can affect the pipeline itself but also the compressor and pumping stations or even the entire environment. Using 2 examples, these physical effects are presented for a gas pressure control station and a process gas line in a chemical plant.

Dr. Patrick Tetenborg

The speed of sound of the grid gas was about 390 m/s for the local conditions. The pulsation frequency of 12.6 Hz led to an acoustic wave length of 31 m. A classical λ/4-resonator has a length of 7.8 m. This length fits very well with the length between the valve of pig 2.1 and the next conjunction (see figure 1).

The excitation of this acoustic resonance seemed to be a vortex shedding – also known as "Karman's vortex". The pulsation frequency of such a vortex depends on the flow velocity. In this case the pulsation frequency of 12.6 Hz did not change during the variation of the total volume flow. The only volume flow that changed very slightly during the total flow variation was the compensation flow in the connection pipe. This possible excitation corresponds with the fact that pulsations only occurred with the open valve in the connection piping. In addition to the identification of the attenuation, the excitation as a periodic vortex shedding at the junction between the connection pipe and pipe 2.1 was also detected.

After this analysis several typical measures are possible to solve this problem. Additional installations can be expensive. Thus, the most simple solution was to change the operating behavior of the connection valve: the connection valve may only be opened when the volume flow is below 2,200,000 m³/h. When the volume flow is above this value, the valve has to stay closed. This solution has been easily programmed in the manifold operation control. Since the realization of this measure no further vibrations occurred.

SECOND CASE STUDY – LONG DISTANCE MEASUREMENTS BY LASER VIBROMETER

A new chemical plant has been built. During the commissioning of a hyper compressor with a discharge pressure of up to 3,000 bars several failed screwed connections at the discharge and interstage piping of the attached reactor bay were detected. It was assumed that elevated vibrations are responsible for these failures. A measurement based investigation was performed to prove this theory.

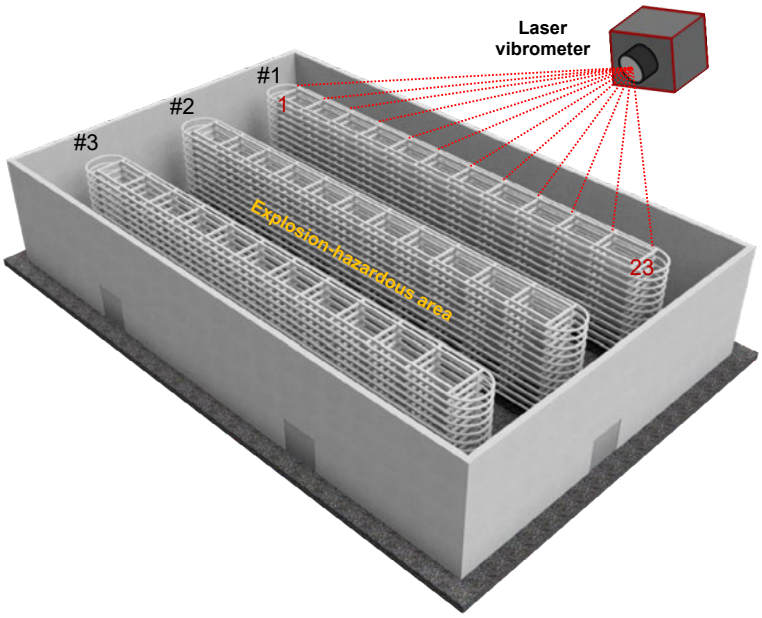

Figure 6: View on the reactor bay with external positioning of the laser vibrometer and different measurement points

The reactors are built up in frames with each more than 50 m long and 10 m high.

The reactor bay is surrounded by a 10 m high wall to meet the required safety standards. The reactor bay itself is of course an explosion-hazardous area with no entrance during compressor operation, see figure 6.

Thus, a detailed investigation of the three reactor frames was not possible in a conventional way. Therefore, a laser vibrometer for contactless measuring over long distances was used to determine the vibration level.

The laser vibrometer was installed on a platform about 100 m away from the reactor bay.

A matrix of the measurement points was defined and the vibration velocities were recorded with the laser vibrometer, see figure 6. This enables a very flexible and short-term choice of interesting measurement positions.

In a first step, it was checked if the vibration level is above the applicable guideline values, see figure 7 for measurement point 1 of reactor frame #1. It resulted that the vibration was dominated by one single frequency, which was 6.6 Hz. This is the second harmonic of the compressor running speed and equals the discharge frequency.

The additional analysis of the visualized measurement points in figure 6 led to further conclusions with regard to the vibration mode, see figure 8.

The vibration mode during compressor operation was dominated by extensive vibrations at the end of the frame and in the center.

Based on these results a resonance test was performed at frame #1 during shut down of the plant. For this purpose an

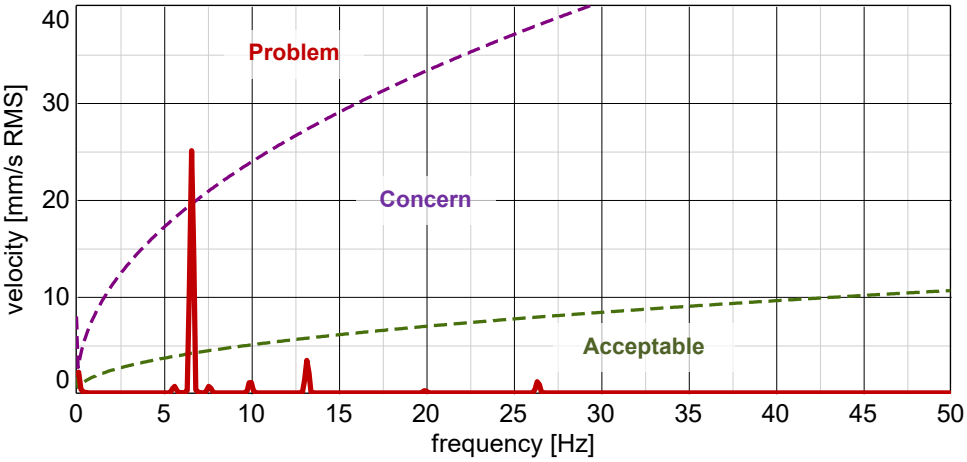

Figure 7: Measured vibration at measurement point 1 of reactor frame #1 in comparison to the guideline values

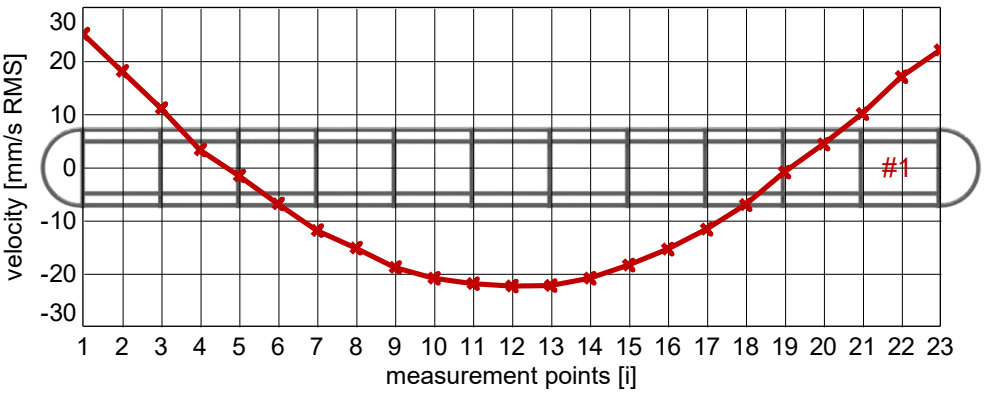

Figure 8: Vibration mode with the local amplitudes and phase correlations of the reactor frame #1 for the dominant frequency of 6.6 Hz

unbalance exciter was mounted to the structure next to measurement point 1. The speed of the unbalance exciter was slowly increased during the test run. With increasing speed an increasing force at the running frequency of the exciter was generated leading to a vibration response of the structure.

The vibration response was characterized by one dominating peak at a single frequency, where the structure replied with high vibrations. This natural frequency was 6.7 Hz and matched the discharge frequency closely.

It was recommended to shift this natural frequency of frame #1. Due to the fixed operation speed of the hyper compressor additional stiffness will solve this vibration problem. Therefore, the installation of additional supports was recommended. The location of this reinforcement has to base on the operational deflection shape.

A check measurement after realization of this measure is scheduled for 2018.

We offer a FREE WEBINAR on this topic on 8 April 2019, 10.00 a.m. (CEST)
Registration: www.koetter-consulting.com

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Figure 1: Comparison of Thicker Scale Plates to a Mobile Phone

HARD DEPOSITS IN BRINE PIPELINES – THE CHALLENGE OF DESCALING AND EXTENDING PIPELINES LIFETIME

Luca Reinhart > Reinhart Hydrocleaning

Abstract

The relationship between company Dow Deutschland Anlagengesellschaft mbH (DOW) with its underground brine chamber sites around Ohrensen, Germany and Reinhart Hydrocleaning SA (RHC SA) is a success story in itself. Prior to explaining the different ways of mechanical cleaning brine pipelines one has to know that RHC SA has worked with DOW since 2007 providing cleaning solutions for different pipelines. Approximately 91 km of DOWs' pipeline network in the area around Ohrensen is cleaned by RHC SA.

PIPELINE TYPES

Cleaning solutions were provided for pipelines sized 6" – 24" used for transporting brine water, mining water or sewage water from the underground caverns around Ohrensen either to the production facility in Stade, the distribution field in Ohrensen or in between the single underground fields.

The pipelines maintained by RHC SA have a total length of approximately 91'000 m ranging in length from 188 m to 27'000 m and are in most cases brine water pipelines (62%), mining water pipelines (33%) or sewage water pipelines (5%).

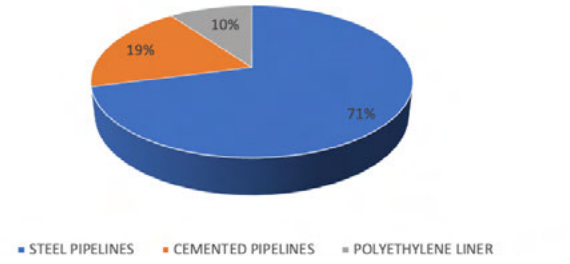

Figure 2: Pipeline Medium of dow Pipelines Cleaned by RHC SA

DOWs' pipeline system is piggable by design and typically feature 3D bends, pig launch and receive facilities along with a draining system to manage the fluids containing scale debris removed by the RHC SA Mechanical Cleaning Tool (MCT). In order to reduce cost, reduce time and maintain throughput, the cleaning tools are driven by the pipeline fluids under normal operating conditions.

Roughly 60% of the above-mentioned total pipeline system length is steel pipeline, followed by polyethylene lined pipelines at around 36% of the total length. A small percentage of pipelines, 3% are cement lined.

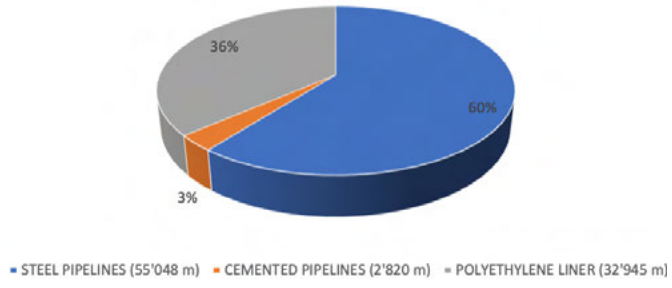

Figure 3: Pipeline Type to Total Dow System Length Cleaned by RHC SA

Compared to the quantity of pipelines cleaned by RHC SA in the Dow Ohrensen system, approximately 71% of the pipelines are made from steel, 19% have a cemented liner and 10% have a polyethylene liner.

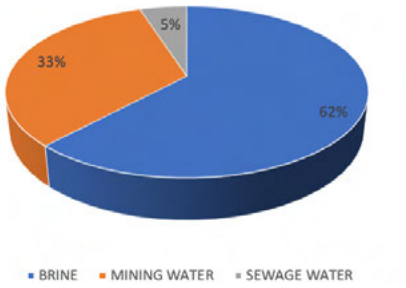

Figure 4: Pipeline Type to Total Amount Of Dow Pipeline System Cleaned by RHC SA

PIPELINE CHALLENGES

Whether it is brine water, mining water or sewage, pipelines need to be cleaned, and the challenge is always to clean the pipeline to clients' need or specification. Having a closer look to the individual pipelines to be cleaned one can see that besides clients' requirements, the MCT needs to be constructed according pipeline specification. Especially in cases where the internal surface of the pipeline is not steel but coated with cement or a polyethylene liner.

The challenge with these types of pipelines is to clean the pipeline to the required standard e.g. for internal metal loss inspection (ILI) without causing damage to the internal polyethylene or cemented coating. The RHC MCT's are designed to meet this challenge and to clean the pipeline in full accordance with the operators' specification to ensure successful ILI.

SCALE BUILD-UP AFTERMATH

Scale build-up, in brine water pipelines typically calcium carbonate (CaCO3), can lead to several issues which have a significant effect of the productiveness of the plant, economically and environmentally:

1. Increased pumping pressure needed to maintain acceptable fluid throughput.
2. Increased pumping speed (RPM) increasing energy consumption and equipment wear.
3. Ever decreasing throughput of amount of pumped pipeline fluids with reducing bore.
4. Increased turbulence inside the pipeline resulting in scale build-up "hot spots" close by e.g. welds, controls and instruments, etc.

The above-mentioned examples caused scale build-up in the pipeline are real scenarios which all pipeline owners try to counteract.

Figure 5: Picture Showing Retrieval of a 24" MCT Flushing Forward Powdered Scale

Hard scale build-up can be removed, mitigated and effectively managed by using the range of Reinhart Hydrocleanings' pipeline specific Mechanical Cleaning Tools enhance.

PIPELINE INTEGRITY

The RHC SA technology is used for two different applications by DOW in Ohrensen. The first is to clean the brine water, mining water and sewage water pipelines to the required standard to ensure production and successful ILI. Inspection can be with MFL (Magnetic Flux Leakage) in steel pipelines and pipelines with polyethylene liner or DMG (Direct Magnetic Response) technology in steel pipelines with cemented liner. A combined mechanical cleaning/inspection campaign is planned and executed usually with a time frame of approximately 1 – 1 ½ months for 10-15 pipelines, depending on length.

Main transport brine water and mining water pipelines are cleaned on a higher frequency for maintenance. For current production figures as e.g. loss of CaCO3 (mg/l) during production in the pipeline, flow, pressure, etc., these pipelines are cleaned three times per year. This ensures continued pipeline performance and integrity. Scale build-up is kept to a minimum level, reducing fatigue of the pumps, controls and instruments whilst maximising production flow ensuring a successful ILI at the next planned intelligent pig run.

EXAMPLE

The difference between a brine water and mining water pipeline is the amount of CaCO3. The concentration of CaCO3 in a brine water pipeline is, understandably, much higher than in a mining water pipeline. The example is the comparison and evolution of each of the pipelines when cleaning with RHC SA mechanical cleaning tools.

The brine water pipeline is made from steel, sized at 24" with an internal diameter of 596 mm and a total length of 19'425 m. This pipeline is cleaned using RHC descaling tools on a regular base three times per year. The type of MCT used for this job is a pulling tool with attached 180° pipeline surface coverage plough arm basic tool with integrated rotating element pin pointing into the scale as well as two modules fitted with two-layer scraping springs that effectively scrape off the scale and reducing it to a powder.

The amount of scale taken out of the pipeline with each run is controlled by the level of mechanical cleaning and the unique integrated bypass that is matched to suit the pipeline size and operating parameters. Most of the powdered scale removed from the pipe wall is flushed forward and captured directly in the plant filtration system. During retrieval one recognizes that the scale is directly pushed in front of the cleaning tool head.

In theory, based on calculation, approximately 3 - 3.5 mg of CaCO3/l is left in the line during production causing the scale to build-up. Assuming, the build-up is uniform through the entire pipeline length, the scale would be determined at 0.55 mm per year. The regular MCT scale removal cleaning runs three times per year shows that the hard scale fragments removed (often called "chips") are thicker than 0.55 mm. This couples to one of the consequences arising by scale build-up.

Since implementing regular maintenance cleaning of the pipeline in 2015 using the RHC SA Mechanical Cleaning Tools, the volume and size of chips has

decreased whilst the amount of powdered scale increases confirming the controlled and efficient removal and management of hard scale.

This pipeline is compared with a mining water pipeline with polyethylene liner, sized at 14" with an internal diameter of 346 mm and a total length of 26'620 m.

The type of MCT used for this job is an adapted modified basic tool head with seven ploughs equipped with rollers.

The MCT was designed with a rolling head and propulsion unit. It has no sharp edges and in total 3 propulsion discs with an adapted bypass with respect to the possible scale existence based on previous cleaning runs by RHC SA.

Figure 6: Picture Showing Scale Chips from a Brine Water Pipeline

Figure 7: Picture Showing Crushed Scale Chips after the Third MCT Cleaning Run in a 14" Brine Water Pipeline

The challenge in cleaning this pipeline is to achieve maximum effectiveness in removing existing CaCO3 scale with zero damage to the polyethylene liner. During design and manufacture of the mechanical cleaning tool, previous RHC experience and cleaning history was considered. Previously in the past, to eliminate any risk of damage to the liner, the MCT was engineered using wood component parts.

The tool body and internals were made from steel with component parts that were in direct contact with or had the potential to contact the pipe wall/liner were made from wood. This MCT design was used twice to clean this pipeline.

To maximize the efficiency of this MCT, the cleaning history and pipeline production data was taken into account. The challenge was not only to construct a cleaning tool that would not damage the liner but also be weight reduced with a maximised bypass to be more effective in terms of scale removal.

This new tool configuration performed extremely well and was so impressive that it was agreed that it should be run three times per year to maximise cleaning efficiency, manage scale removal and build up during normal operations. The amount of scale plates brought out by the MCT made a great visual impact. As no scraping springs were used, the amount of powdered scale was zero but the amount of thick scale plates taken out was remarkable.

PROGRESSIVE EFFECTIVENESS

Pipelines carrying various products whether these are oil, gas, chemicals, water, utilities etc. have different cleaning requirements, specifications and challenges.

A progressiveness approach to the cleaning of these kinds of pipelines with a range of mechanical cleaning tools, often standard off the shelf pigs, is common. In most cases, the pipeline owner will run standard pigs for maintenance but will often not know internal condition of the pipeline in terms of cleanliness. A typical cleaning program, using cleaning tools designed, developed and implemented by RHC SA can be described as progressive. How-ever, com-

Figure 8: Picture Showing Receiver of the 14" Mining Water Pipeline

pared to the traditional approach employed by others, it can be described as a more effective and efficient approach that guarantees results.

A key difference to traditional pipeline cleaning programs is that RHC SA uses their mechanical cleaning tools initially from the first run onwards. The use of multiple poly pigs (bare and coated), gauge plate pigs and cup pigs prior brush pigs are unnecessary. RHC SA start to clean from the very first run and increase cleaning performance by adding and combining different cleaning elements to the mechanical cleaning tools. Using this procedure, the total amount of cleaning runs decreases with a simultaneous increase in cleaning efficiency and performance reducing not only the costs per cleaning run but also reducing the risks of potential exposure to people and environment by limiting the amount of pipeline pig launch and receive trap operation.

Besides the descaling of pipelines from hard deposits such as CaCO3, the mechanical cleaning method of RHC SA could also be of interest when it comes to pre- commissioning gas pipelines that transport e.g. oxygen, nitrogen and hydrogen.

Other areas of expertise are in dewaxing oil pipelines and cleaning water injection pipelines subject to MIC (Microbiologically-Influenced Corrosion). RHC SA adapt their Mechanical Cleaning Tools' to achieve the required level of cleanliness necessary to ensure safe continuous operation, manage pipeline integrity and performance whilst maximising throughput.

In the end it is "not the number, but the quality of cleaning runs" that is important.

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WHERE TECHNOLOGY MEETS NATURE: A UNIQUE APPROACH TO BAN ILLEGAL TAPPING

Abstract

Illegal tapping is a growing problem on a worldwide scale. A recent example in Mexico highlights why pipeline managers across the world should be cautious of this costly crime. Besides the financial consequences of illegal tapping, the integrity of the pipeline and the increased risk for a smooth continuous operation can be detrimental for an operator. While in some cases, loss of pressure in the pipeline can be detected using advanced measurement and inspection tools, in other situations, the mass balance does not give a clear answer on the loss of product. In all cases, finding the position of the illegal tap along the pipeline is always a challenge. Illegal taps are installed in a professional manner following the best practices. However, in most cases, a small spill during the installation or during the tapping process itself is highly feasible. One simple drop ending in the soil at 2 - 3 m underground is sufficient to leave a scent trace for sniffing dogs. While these small traces are often difficult to detect or are even undetectable using leak detection equipment, the highly sensitive noses of sniffing dogs can detect these small leaks caused by illegal tapping activities. In this article we will discuss today's challenges regarding illegal tapping and explain sniffing dogs' capabilities.

INTRODUCTION

Oil and natural gas are still the world's leading energy sources with a market value larger than valuable raw material markets combined. An enormous number of pipeline networks across the globe are used to transport these energy resources from exploration and production sites to consumers through extreme geological and hazardous environments. Since these modes of resource transportation are of high value, leakages, pressure loss, faults in structural integrity, as well as illegal tapping can be detrimental to the environment, in the process incurring huge losses for the respective stakeholders as well.

Even with advanced, evolving and cutting-edge technological solutions, pipeline environments require intelligent and unconventional use of pipeline management and inspection approaches. However, new techniques sometimes have major limitations when put into practice. Existing underground pipeline systems are not always designed to be used with the newest techniques and having them adapt to the latest technology requires huge investments, running into billions of dollars.

Due to these technical limitations, as well as high environmental and economic threats, the pipeline leak detection market has raised its demand for a more effective approach to identify leaks in an economic, fast and efficient way.

Unlike high-end technology, simple, conventional methods such as the use of Sniffer Dogs can prove to be the cost-effective, easy-to-deploy and customised offering for pipeline leak detection. Trained sniffing dogs have a natural capability to detect specific smells. The sensitive nose of sniffing dogs, in combination with a lengthy and thorough training journey, makes it possible to search for leaks in underground pipelines.

ADVANCED TECHNOLOGIES: CHALLENGES

To minimise occurrences of physical threats and avoid personal injuries and transportation disruption, a combination of external and internal inspection, as well as detection tactics using technology have been put in place.

Besides the fact that new technologies often show major limitations when applied in practice, underground pipeline systems are not always easily compatible with technologies such as intelligent pigging, fibre optic cables or sensor technology, and adaptation costs require huge investments or set-up expenses. Moreover, underground pipelines that are able to use these leak detection techniques have limits that are often mentioned in barrels per day and leave too much room for error. In turn, this causes a high risk of pollution and increases soil remediation costs up to millions of dollars each week.

> *"Dogs have helped in writing history and will surely help us writing the future.*
>
> *Kristof Verwaest*

DOGS CAN GO WHERE MACHINES CAN'T

Sniffing dogs have been found to be extremely effective in these scenarios. They have highly sensitive noses, which are unmatched against high-tech available measuring instruments. Usually, the most advanced detection equipment available today have parts-per-million sensing levels, which are limited when it comes to discovering minuscule leaks of underground pipelines. This equipment must also be handled by multiple technical professionals and is difficult to be used in harsh environments, rural areas and remote locations.

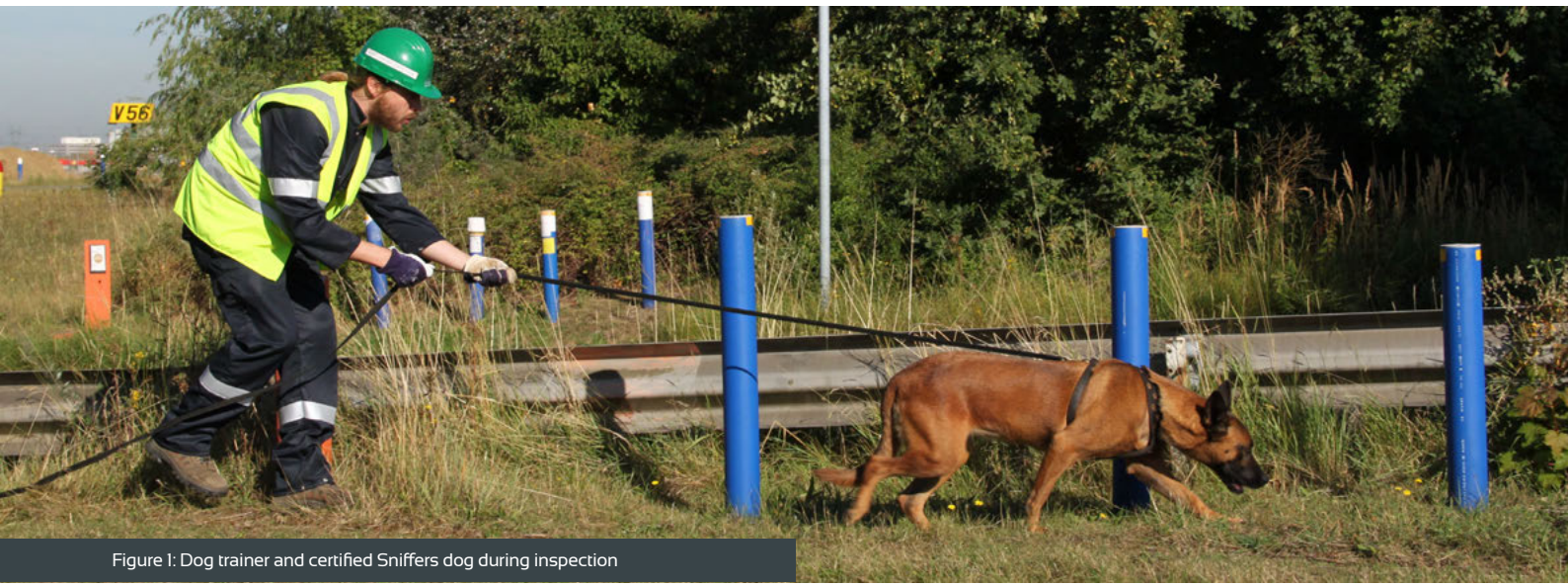

Figure 1: Dog trainer and certified Sniffers dog during inspection

> *"Leak detection dogs will play a key role to attack the search for illegal tapping and gas-leaks on ageing pipelines.* Kristof Verwaest

On the other hand, dogs naturally have the capability of sniffing up to parts per billion, which makes them more accurate. They can access rural, difficult terrain, making them environmentally apt. They need few handlers, which makes the mission more effective; and can sniff gases, fluids and treated water – substances that limit machines.

Combined with a lengthy and thorough training journey, the mobility of sniffing dogs can access underground pipelines and can bring their nose above pipelines that are in rural areas, through woods, across mountains or through fields. This makes several detection instruments obsolete for such circumstances at an acceptable pace.

For example, Belgian pipeline companies and the country's Ministry of Economic Affairs recognised the capabilities of sniffer dogs as a reliable and efficient survey of the underground pipelines and they included sniffer dogs in the latest official technical standards for pipeline management as a valuable leak detection method.

ILLEGAL TAPPING A MAJOR SOURCE OF CONCERN

With an annual production valued at $1.7 trillion, a flourishing black market for oil is no surprise. About $133 billion worth of fuel is stolen or adulterated every year, which fund dangerous practices. According to Oilprice.com, the top five countries accused of oil trafficking are Nigeria, Mexico, Iraq, Russia and Indonesia. It is estimated that Nigeria alone loses $1.5billion a month due to pipeline tapping. Just a short while ago, a devastating pipeline explosion due to pipeline tapping in Mexico, killed about 100 people. This might have been an extreme case in Mexico, but it's not limited to this country as the number of illegal tapping is rising in the western countries.

Recent examples in the UK, Germany, France, Indonesia and Mexico have highlighted why pipeline managers across nations should be cautious. Apart from the fact that there are financial consequences of illegal tapping, the structural integrity of the pipeline and the increased risk for a smooth, continuous operation can be damaging for a pipeline operator as well as the environment around it. Sometimes, loss in pressure in the pipeline can be discovered through advanced measurement tools but many times the mass balance does not give a clear picture of the loss of fuel. However, in all cases, the illegal tap is always made difficult to find as it is vital for crooks.

Figure 2: Heading towards a potential leak

To a certain extent, technology is also to blame. As the technology to maintain, monitor and manage pipelines advances, so does the process to install illegal taps in a professional manner - following the best practices.

> *"The better I understand technology the more I believe in using dogs.*
>
> *Kristof Verwaest*

However, in most cases, a small spill during the installation or during the tapping process itself is highly likely. One small drop ending in the soil at two-three metres underground can leave a scent trace for sniffing dogs. While these small traces are often difficult to detect or are even undetectable using advanced leak detection equipment, the highly sensitive nose of sniffer dogs can pick them up.

Figure 3: Sniffers dog Senna marking a leak

QUICK REDRESSAL

The detection of illegal tapping at an early stage is crucial to guarantee both the continuity and the integrity of your pipeline infrastructure. Soil remediation and expensive excavation are additional challenges that need to be avoided at all costs. Unfortunately, in most cases, the theft has already occurred before the illegal tap is detected. In fact, the pipeline owner might not even be aware of these illegal activities at all.

For example, loss of pressure on a pipeline network in Georgia was the first indication of a potential illegal tapping. Several kilometres of underground pipeline in non-residential areas, and so without any permanent observation, nourished the suspicion of an illegal tap. As the first measure, the pipeline manager checked the network every day by guards on horses. However, no single visual indication of fraudulent activity surfaced. Sniffing dogs were hired to screen the suspicious network over 20 kilometres.

Using two teams, each consisting of one sniffing dog and its handler, surveyed the underground pipeline during a two-week project. Supported by armed guards, a specific location in an open area, without any buildings or trees, was identified by both dogs, what seemed to be an impossible location. Detection of the exact location of this illegal tap was a breakthrough for the pipeline manager to avoid financial losses and increased risk due to the integrity of the underground network.

ENHANCING DETECTION WITH DOGS

Multiple industry case studies comparing leak detection dogs to other existing techniques have shown the technical capabilities of dogs to be superior. When it comes to evaluation of the necessary investments, precise leak detection methods with equipment require measurements underground and exactly above the pipeline to meet the higher demands. This method requires manpower to localise the pipeline, drill holes at least at every metre, do leak detection at every metre and for the additional logistical support.

This complex approach to meet future legislation allows for the progress of only a few hundred metres per day. Dogs, on the other hand, have the same detection capacity, even from a distance, and require only one handler per animal to have the progress of multiple kilometres per day. This positions dogs as future legislation proof with a realistic financial budget.

Having said that, measurement equipment can be effective but also has its limitations. Technology meets nature, however, when measurement equipment is used in parallel with sniffing dogs. Both methods have their capabilities and limitations but when combined, it is clearly a win-win situation.

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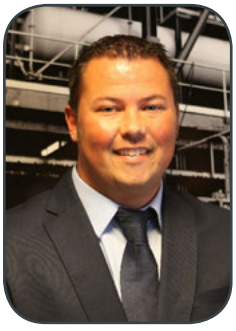
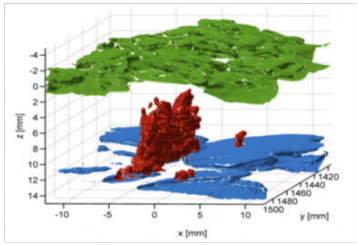
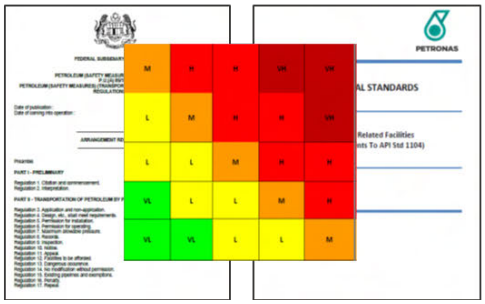




Intelligent Weldment Inspection DSS

Artificial Intelligence System with Robust Anomalies Assessments



Risk & Reliability-based Anomalies Acceptance

Revolutionising Pipeline Safety: Intelligent Weldment Inspection Decision Support System

Mohd Nazmi bin Mohd Ali Napiah, Hambali bin Chik > PETRONAS

Abstract

The costs of pipeline failure are immense i.e. fatalities, environmental damages, loss of revenue and reputation. EGIG and OGP provides solid evidences and causal analyses of pipeline failures. PETRONAS has a structured methodology and system in eliminating pipeline failure. Nevertheless, failures do happen on newly constructed pipelines and those failures were due error in evaluating weldment inspection results.

Thus, there is an imminent need for industry to establish a robust approach and technology in addressing the issue. Currently, the industry is heavily dependent on human i.e. inspectors in interpreting weldment anomalies and mis-interpretation occurred resulted in pipeline failures and cost hundred millions of ringgit of opportunity losses. An intelligent welding inspection decision support system could significantly reduce human intervention and eliminate mis-interpretation. This paper will touch on the overall pipeline incident statistics worldwide as well as in PETRONAS. It will discuss on two critical management systems that PETRONAS employs to ensure pipeline system is designed, constructed, tested, operated and maintained safely and reliably i.e. the PETRONAS' Project Management System and Pipeline Integrity Management System. The ultimate would be discussion around the concept and inspired capabilities of an Intelligent Weldment Decision Support System.

INTRODUCTION

PETRONAS is currently operating around 12,000+ kilometers of offshore and onshore pipelines in East and West Malaysia. About 25% of the pipelines are onshore's natural gas and fuel hydrant pipelines while the remaining 75% are offshore's full well stream, condensate, wet gas, crude, water injection and gas injection pipelines. Among the relatively newest onshore pipelines are the Sabah-Sarawak Gas Pipeline (SSGP) and Kuala Lumpur International Airport 2 (klia2) fuel hydrant pipeline that carries jet A1 for fueling air planes. The SSGP transports natural gas from Sabah Onshore Gas Terminal (SOGT) in Kimanis, Sabah to Malaysia LNG Sdn Bhd (MNLG) plants in Bintulu, Sarawak. Both SSGP and klia2 fuel hydrant pipeline were constructed in 2011 and commissioned in 2014.

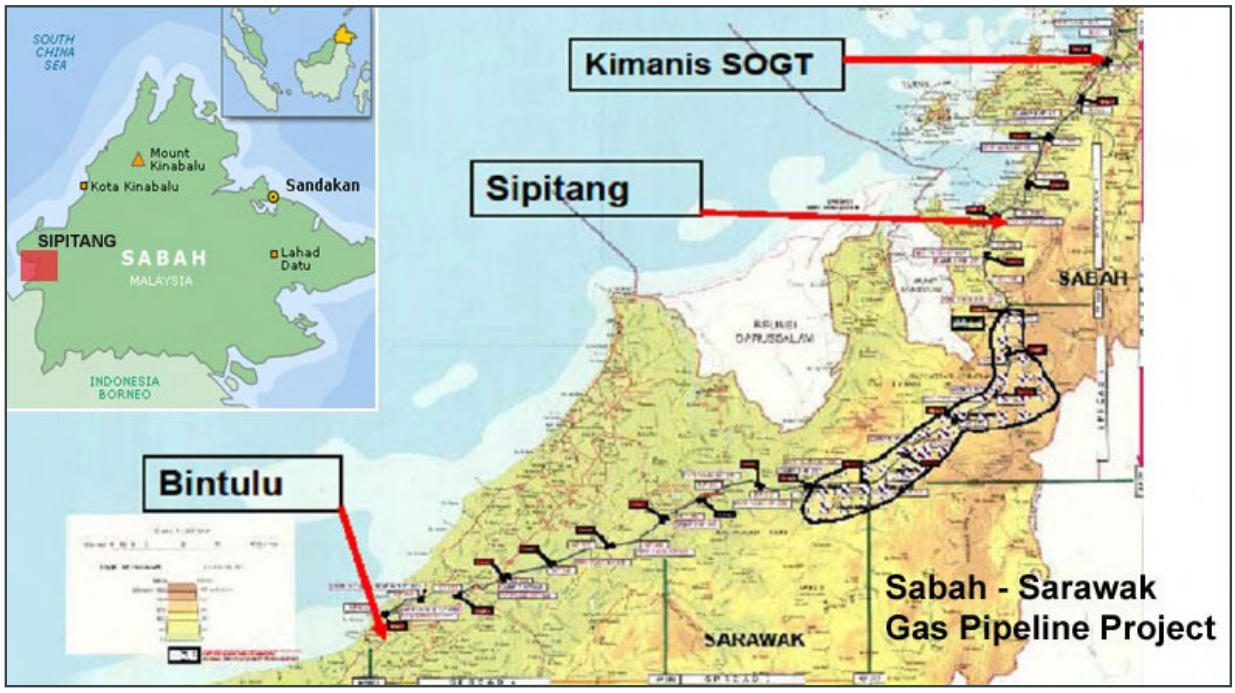


Figure 1: Schematic map of SSGP – from SOGT to MLNG (courtesy of sedia.com.my)

Figure 2: Photo showing main structures of klia2 – the fuel hydrant pipeline is buried under the airport tarmac area (courtesy of Malaysia Airport Holding Berhad)

PETRONAS' PIPELINE INTEGRITY MANAGEMENT SYSTEM (PIMS) AND PROJECT MANAGEMENT SYSTEM (PPMS)

In PETRONAS, a pipeline system is managed from design up to abandonment via a structured PIMS. PETRONAS' PIMS consists of fourteen (14) elements namely:

1. PIMS Charter and Strategic Objectives
2. Management Leadership and Organisation
3. Document Control and Management Information System
4. Capability Management
5. Integrity and Risk Management
6. Engineering, Procurement and Construction
7. Commissioning, Handover and Abandonment
8. Normal Operations
9. Inspection and Maintenance
10. Stakeholders Awareness and Emergency Response
11. Accident/Incident Investigation and Analysis
12. Repairs and Modifications
13. Management of Change
14. Compliance Review and Audit

A manual is established to outline the requirements for each of the element and one can see and realise that by adhering to the PIMS, a pipeline operator shall receive a pipeline system from project team that is designed, constructed, tested and commissioned as per industry and regulatory standards. And the pipeline operator shall operate and maintain the pipeline system safely, reliably and efficiently.

To reinforce the importance of delivering any green and brown field projects in PETRONAS, a dedicated management system is also established. The above pipeline assets are engineered, constructed, tested and commissioned following PETRONAS Project Management System (PPMS).

PPMS governs the management of green and brown field projects in PETRONAS. In the heart of PPMS consists of gated process from Front End Loading (FEL) 1, 2, 3, execution phase, and start-up and operation of project.

The aim of PPMS is that any project shall meet the schedule, cost and fit-for-purpose in terms of operability of assets e.g. pipeline system, petrochemical plants, offshore development. It employs project management standards in a form of methodologies and tools to aid project management executives and practitioners in day-to-day activities related to managing of major as well as smaller projects.

Those tools ranges from framing business opportunity, front end loading management, cost engineering, project control, construction management, contractor and contract management up to engineering, risk, HSE and commissioning and start-up managements.

Hence, from management system's perspective, both pipelines are supposedly be at the top of its performance providing return to PETRONAS' investments right from starting on operation up to its intended design life.

PIPELINE INCIDENTS

The SSGP and klia2 fuel hydrant pipeline experienced leak, respectively i.e. in August 2014 and January 2018 for SSGP; and in July 2014 and October 2015 for klia2 fuel hydrant pipeline. From root cause failure investigations, among main contributor was from anomalies at the pipelines' girth weld. To be exact, it was mis-interpretation of 'un-acceptable' anomalies to be 'acceptable' anomalies during

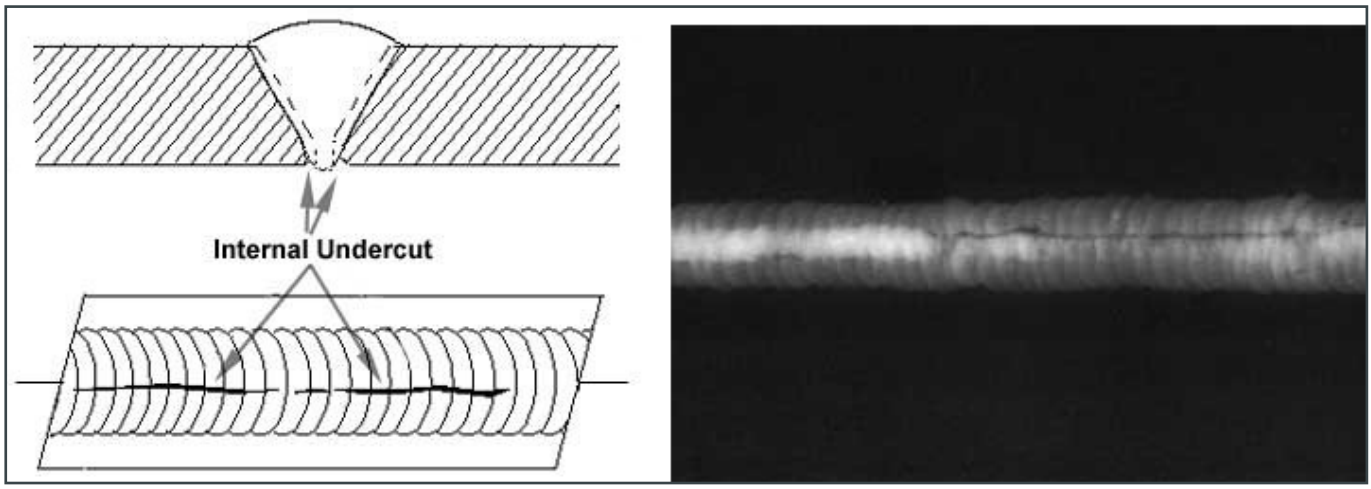


Figure 3: Example of view of girth weld film showing root undercut anomaly (courtesy of www.nde-ed.org)

project construction phase by welding/NDT inspectors. As a result, from the investigations, all 40,000+ of SSGP's and 12,000+ of klia2 hydrant pipelines' girth weld x-ray films had to be meticulously re-evaluated and re-confirmed by multiple level of welding/NDT inspectors.

On top of that, both pipelines had to be shut down for many months and arduous inspections and integrity assessments were performed for assurance of integrity and to eliminate recurring of similar incident. One can only imagine the amount of business opportunity losses of shutting down the pipelines as well as tangible 'cost of non-conformances' of correct and accurate interpretation of girth weld anomalies.

The author of this paper was involved in both incident investigations, inspections and integrity assessments; and utmost important to stress that a 'PARADIGM SHIFT' and 'GAME CHANGING' of approach/mindset/technology must be done so that welding anomalies quality control and assurance is less dependent on human intervention and similar kind of incidents can be eliminated totally.

It needs to be carefully noted as well that despite having a structured, good management systems for overall pipeline integrity management and project management, such major incidents or failure can happen since 'human intervention' is part of the system.

Now question or opportunity for improvement arise in such a way that can critical activities in pipeline construction e.g. weldment acceptance and interpretation be made with virtually no human intervention?

Now, arising from the incidents, PETRONAS has enhanced its requirements of welding/NDT inspectors and interpreters by way of procedural, quantity of inspectors/interpreters as well as their competencies.

www.Inspection-for-Industry.com
Quality Control Form

WELDING DAILY REPORT (PIPING)

Project:
Client: | Report No.:
Contractor: | Date:
Ref. Standard: | Page 1 of 1
Doc. No.:

Area/ Location: | Ref. Drawing: | Rev.

Line No.	Spool No.	Joint No.	Joint Type	O.D	Thk.	Welder (s) ID Root	Hot	Cap	Type of Material/Material Spec. ..... to	WPS No.	Pre-heat	PWHT	Fit up Report No.	VT Result	Remarks

Technical Comments:

Abbreviation:
Acc. : Accept **Rej.** : Reject **RC** : Re-Cap **NA:** Not Applicable
B: Butt Weld, **S**: Socket Weld, **T**: Seal Weld (for Threaded Joints), **M**: Miter
For Example: Pipe / 5L X52 **to** Flange / A105

Quality Control	TPI Inspection	Client
Name: Sign: Date	Name: Sign: Date	Name: Sign: Date:

Figure 4: Typical welding report with three levels of review and signatory i.e. Quality Control, TPI (Third Party Inspector) Inspection and Client (courtesy of www.Inspection-for-Industry.com)

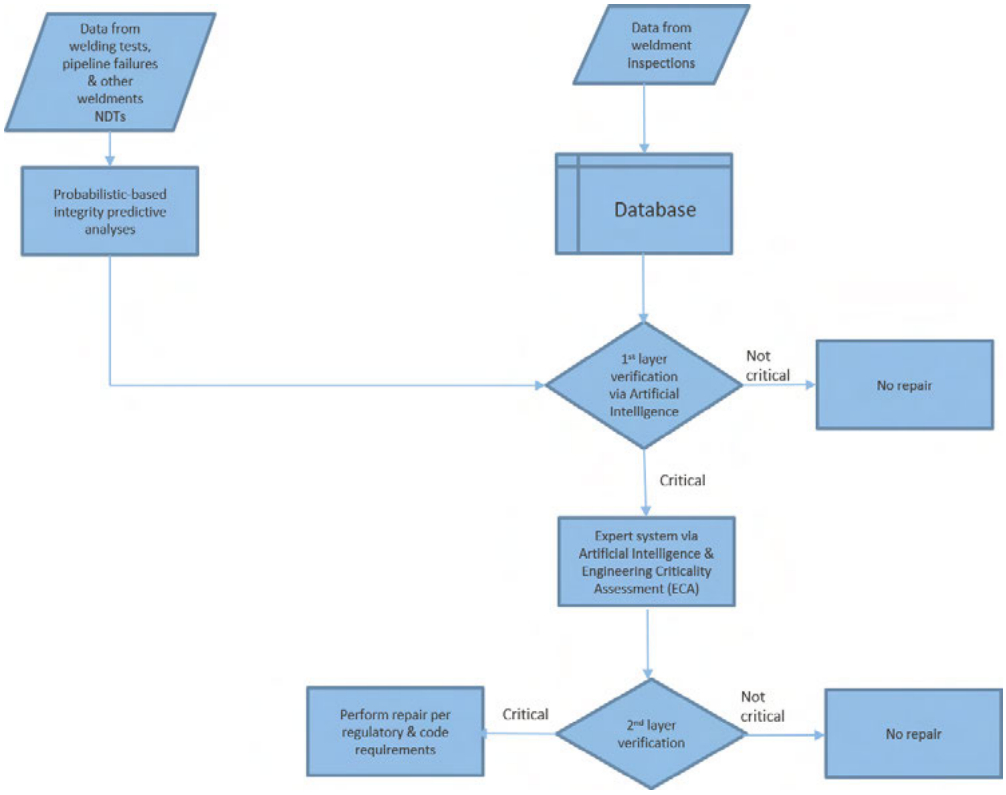


Figure 5: Process flow of i-WIDSS™

INTELLIGENT WELDMENT INSPECTION DECISION SUPPORT SYSTEM (I-WIDSSTM)

It is envisaged that i-WIDSSTM is an integration and advancement of various technologies/methodologies and regulatory/codes requirements. It will consist of

i. advanced weldment inspection technology that should be able to accurately identify, locate and size all types of weldment anomalies,
ii. artificial intelligence system with robust weldment anomalies 'patterns' assessment, and
iii. risk and reliability-based weldment anomalies acceptance criteria as an alternative to typical welding code requirements.

Figure 5 depicts process flow of i-WIDSSTM where the system supposedly continuously 'learning' various weldment anomalies in the database via data from welding/ weldment tests, weldment failure investigation analyses, weldments NDT records and weldment inspection findings from a specific pipeline project in the first layer verification check. If any anomaly does not pass the first layer, it will proceed to second layer where customised engineering criticality assessment will be built into the system and automatically conduct the verification. Only then an anomaly will be decided that it can remain or require to be repaired. It needs to be noted that the weldment anomaly acceptance criteria will be tied to either risk or reliability-based approach of which the intelligent system will be assessing it according to specific algorithms.

The i-WIDSSTM is anticipated to provide tremendous benefits to PETRONAS as well as the industry i.e. less manpower and time required from inspection of girth weldment up to decision on the acceptability of any weld anomalies i.e. approximately 30-50% lesser manpower and time. This could translate to hundred thousand to millions of monetary savings to a project, depending on the size of pipeline project. Most importantly human error or 'mis-interpretation' of weld anomalies can be avoided thus such failures as experienced by PETRONAS shall be 'thing of past'. PETRONAS is considering for a joint industry project (JIP) for the development of i-WIDSSTM of whom the author can be contacted at nazmi@petronas.com.my.

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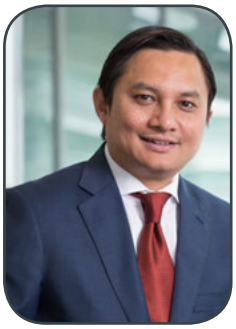

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CROATIAN GAS CENTER Ltd.

CROATIAN GAS ASSOCIATION
MEMBER OF IGU

34TH INTERNATIONAL SCIENTIFIC & EXPERT MEETING OF GAS PROFESSIONALS
OPATIJA, CROATIA, 8 - 10 MAY 2019

STRENGHTEN YOUR COMPANY'S POSITION AND SHOWCASE EXPERTISE TO OVERCOME THE CHALLENGES OF THE GAS INDUSTRY

Present your products and technical solutions in front of 600 gas experts,
mostly managers of the leading Croatian and European gas and energy companies

CONFERENCE TOPICS

1. CURRENT STATE AND TRENDS OF GAS RESERVES IN THE WORLD, EU AND CROATIA REGARDING CURRENT AND FUTURE CONSUMPTION
2. EFFICIENT TECHNOLOGIES AND THE USE OF GAS WITH RENEWABLE ENERGY SOURCES
3. FUTURE CONSTRUCTION OF GAS INFRASTRUCTURAL FACILITIES IN CROATIA AND IN EUROPE
4. SMART TECHNOLOGIES IN GAS AND ENERGY SYSTEMS
5. INNOVATION AND TRANSFER OF TECHNOLOGIES AND THEIR ROLE IN THE GAS INDUSTRY
6. TODAY'S GAS MARKET IN THE EU AND CROATIA AND CHALLENGES IN THE FUTURE
7. ISSUES RELATING TO GAS DISTRIBUTERS IN TERMS OF SYSTEM EFFICIENCY AND SECURITY
8. THE POTENTIAL OF THE USE OF GAS IN TRANSPORT AND ASSOCIATED ISSUES
9. TECHNICAL REGULATIONS, RULES OF THE PROFESSION AND CONSUMER RIGHTS
10. POSTER SESSION ON VARIOUS ENERGY TOPICS

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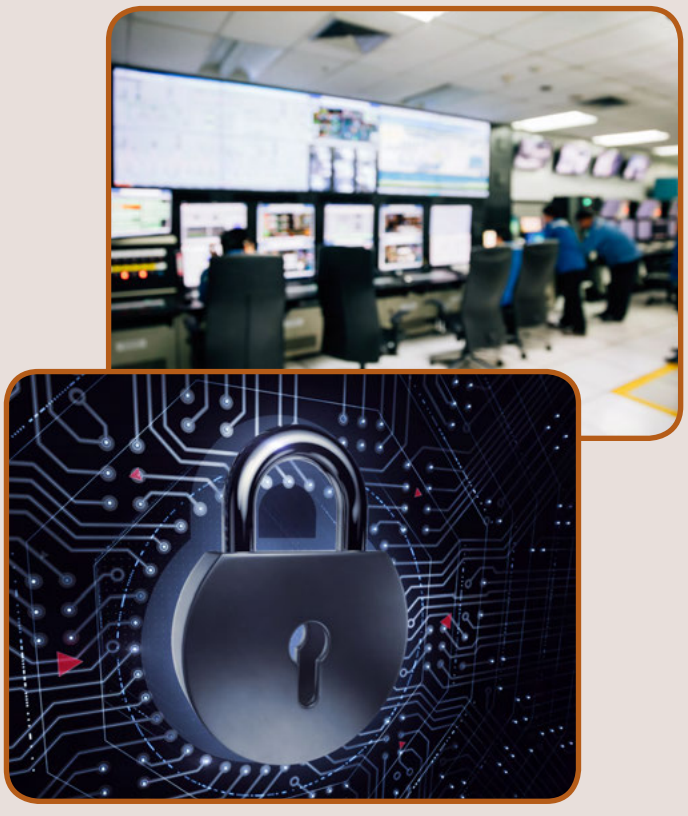
Croatian Gas Center Ltd., Heinzelova 9/II, 10000 Zagreb, Croatia, **phone:** +385 (0)1 6189 590, **e-mail:** opatija@hsup.hr

May 2019

In the next Edition of ptj:

Digitalization in the Pipeline Industry



The next issue of Pipeline Technology Journal (ptj) will address Digitalization in the Pipeline Industry.

This is a great opportunity for skilled authors to submit insightful papers and to contribute to the global pipeline industry's constant professional exchange.

NDT Global Announces Two Major Advances In Pipeline Inspection Technology

NDT Global, a supplier of ultrasonic pipeline inspection and integrity services, announced two major advances in pipeline crack inspection technology.

Enhanced Sizing methodology can size cracks to 100% wall thickness.

NDT Global UCx Enhanced Sizing methodology is capable of sizing the full range of crack depths up to 100% wall thickness. The removal of depth sizing limitations provides operators with more accurate data for better informed decisions regarding pipeline operations.

"We're extremely proud of what our team has accomplished," said Richard Matthews, NDT Global President and CEO. "One of these breakthroughs would have been an achievement. Introducing a solution that incorporates two industry firsts is remarkable."

NDT Global has improved depth sizing accuracy of its industry-leading UCx technology by 20%. This advancement further enhances the data that operators rely on for safe operation of their pipeline assets. UCx Enhanced Sizing is designed specifically for high-precision inspection of axial cracks in welds. This level of precision is shown in its POD (Probability of Detection) specification for axial cracks, crack-like anomalies and linear indications equal to or greater than 99%.

New Evo Eclipse UCx Technology is the first to overcome tilt and skew limitations.

"Evo Eclipse is one of the most important advances in the history of ILI technology," said Dr Thomas Hennig, NDT Global's Technology Advisor. "It builds on the strengths of Evo Series 1.0 UCx."

In addition to the benefits delivered by UCx Enhanced Sizing, Evo Eclipse offers a sensor configuration that provides the capability to identify and accurately size tilted and skewed cracks, e.g. hook cracks or cracks at the bevel of typical DSAW seams.

Along with enhanced capabilities for accurately detecting and sizing tilted and skewed cracks (hook cracks), a new ILI critical-feature detection capability supports the replacement of hydrostatic testing with ILI critical feature detection. Inspection efficiency is further optimized by the system's ability to combine crack, metal loss, and geometry inspection. These dramatic improvements reduce operator risk while minimizing the total cost of asset management.

"High-resolution Evo Eclipse crack inspection technologies offers operators more accurate results, with tighter depth-sizing tolerances," Matthews added. "We are confident Evo Eclipse will become the new standard for reliable, efficient, and accurate pipeline inspections."

Evo Eclipse – Next Generation Cracking Technology

The leading Southeast Europe' s international gas conference and exhibition will be held in May in Opatija, Croatia

Croatian Gas Center Ltd. and Croatian Gas Association, member of the International Gas Union (IGU) are announcing the 34th edition of the International Scientific & Expert Meeting of Gas Professionals, which will be held from 8th to 10th of May, 2019 in the Congress Centre of the Grand Hotel Adriatic, in Opatija, Croatia.

One of the largest three-day international gas conferenceS & exhibitionS in Central and South-East Europe will once again gather 600 distinguished gas and energy experts and managers from about 230 gas companies and institutions, 45 exhibitors from 20 and more countries. Conference will cover a number of current issues relevant to the gas economy and energy industry that stretch along the entire natural gas chain.

In the first keynote speech Francisco de la Flor, director of Enagas and the vice-chair of the International Gas Union Task Force 3 will present the Triennium Working Program 2018-21 of the IGU Task Force 3 – Energy policy. The TF3 will address the main topics under IGU´s scope, which are: Greenhouse gas emissions; Air quality; Gas & renewable energies; Gas for transport; Energy access & economic development; Energy efficiency.

Prof. Igor Dekanic, D.Sc. from the Faculty of Mining, Geology and Petroleum Engineering, University in Zagreb, will elaborate the basic elements of geopolitical influences on the use of gas sources and available transport routes in a changing market conditions.

Gas expert Stevo Kolundzic, D.Sc. will speak about natural gas prices predictability in comparison to other energy sources. Prof. Dr. Ing. Gerhard Schmitz from the Hamburg University of Technology will give a short overview about energy storages for resilient energy systems with a high amount of renewables and he will mention the meaning of gas as a storable energy carrier.

Many paper presentations will discuss the issues relating to gas distributers in terms of system efficiency and security. Dr. Jeffrey M. Seisler, CEO of Clean Fuels Consulting, will present an interesting speech titled „Funding Opportunities for NGVs: A Roadmap to Brussels" on the potential of the use of gas in transport and associated issues like the opportunities in financing from EU funds of development projects for NGVs.

In addition to verbal presentations of scientific and professional papers a poster session will be held, featuring papers by numerous experts from different energy sectors.

Gas Equipment and Technology Exibition

The conference will be followed by the gas equipment and technology exhibition which will bring together 45 local and foreign exhibitors, mainly manufacturers and dealers of gas equipment, as well as many other renowned companies which will present its advanced technical solutions for the gas and energy industry.

All companies – gas market participants are invited to take advantage of this unique opportunity to present its products, services and projects by exhibiting gas equipment and other advanced gas technologies solutions, promotional posters, leaflets and brochures on indoor and outdoor exhibiton units.

Sponsorship of this established gas event provides a unique opportunity for companies to strengthen their position, showcase expertise and new technical solutions needed to overcome the challenges of the gas economy industry.

For more info please visit the event website: https://susret.hsup.hr/en/
and contact:

Croatian Gas Centre Ltd. & Croatian Gas Association
e-mail: opatija@hsup.hr ; phone: +385 (0)1 6189 590

HERRENKNECHT
Always moving forward in pipeline technology

A dense pipeline network spanning over three million kilometers is the global backbone of industry and commerce. To keep supply stable, innovative pipeline companies are constantly expanding the network and making it denser even in sparsely populated places. In the pipeline business too, Herrenknecht is a dependable partner supporting its contractors throughout the duration of every project. Groundbreaking pipeline tools close technology gaps and offer individual solutions for any project challenge.

Every year, around 380 kilometers of new pipelines are installed worldwide using Herrenknecht technology. Thanks to innovative technology developments such as Direct Pipe®, pipelines can be installed quickly and securely even in difficult topologies. Crossing under a hurricane protection levee in Texas, Direct Pipe® met even the stringent safety requirements of the US Army Corps of Engineers. The method combines the advantages of microtunnelling and HDD technology. In a single step, a prefabricated pipeline can be installed trenchless and the required borehole excavated at the same time.

In Auckland, for example, Direct Pipe® proved itself in the modernization of a wastewater treatment plant. Here the Herrenknecht Utility machine set a new distance record: it bored its 1,930 meters long way through the New Zealand subsoil into the sea. By using the innovative technology, harmful environmental effects on the underwater flora were minimized. The company also offers HDD expertise for pipeline installations like this from the mainland to the seabed (shore approach). In Anglesea, Australia, the Dunstans Construction Group replaced the sea outfall pipe of a water treatment plant cut off by a collapsing cliff using a Herrenknecht HK250C rig within a few months.

HDD rigs from Herrenknecht are part of contractors' standard repertoire for river crossings too. South Paris, as part of a canal extension, the ten meter deep Canal latéral à l'Oise running parallel to the river Oise was widened and deepened to accommodate large vessels. The existing gas pipeline had to be lowered by eight meters and replaced. After only a week, the approximately 250 meter long and 18 meter deep river crossing was successfully completed. A special feature of this project: the HK80CK rig used is hybrid and powered by both a diesel engine and an electric motor. Once the rig is in position, only the electric motor runs during the drilling process, resulting in lower exhaust emissions. In urban areas in particular, the compact rig stands out with its space-saving design, while its low noise levels can increase acceptance of construction work among the population.

Mechanized excavation technology is also used for the extraction of resources. With entry angles between a shallow 8 and a vertical 90 degrees, coal seam gases and oil sands at depths of up to 2,000 meters can be tapped using Slant Directional Drilling (SDD). In Zevenbergen in the Netherlands, renewable geothermal energy accessed by Herrenknecht deep drilling rigs is used to heat multiple greenhouses. The principle is simple: a well raises the warm water from a depth of 1,535 meters. Then, after the heat has been extracted, the cold water is pumped down a second well back into the reservoir.

To drive advances in the pipeline market, Herrenknecht is constantly working to improve existing pipeline technologies. In close cooperation with HDD specialists, for example, innovative tools have been developed that greatly simplify the previously multi-stage reaming process. The Full Face Hole Opener (FFHO) is a milestone in HDD pipeline installation as it enables the efficient reaming of pilot holes in a single step. The Downhole Jetpump (DHJP) removes the drill cuttings in the drill string itself and not through the borehole. This means HDD boreholes are cleaned much more effectively and safely than before. The tools can be used individually or in combination to help to get the best results from any project.

With around 80 domestic and and overseas subsidiaries and associated companies working in related fields, Herrenknecht provides comprehensive fast and targeted services close to each project and contractor. In late 2018, a new HDD service hub opened in Houston, Texas, right in the heart of the American pipeline business. The U.S. state is the world's sixth largest oil producer. With its location, the company is now even closer to the center of the U.S. oil industry.

Discover more pipeline challenges in the Herrenknecht online magazine All Around #9 "Focus on Pipeline": https://allaround.herrenknecht.com/en/issue-9.html

Metegrity's Pipeline Enterprise Software Captures Digital Data, Accelerates Production on North America's Largest Pipeline Project

Project:
Enbridge Line 3 Replacement 36-inch 1,000km Pipeline

Enbridge, a multinational energy transportation company, has selected Metegrity's Pipeline Enterprise software as its construction quality management system (CQMS) for the largest pipeline project in North America: the Enbridge Line 3 Replacement Pipeline.

The 36-inch, 1,000 km pipeline project is approaching final stages, and it has already benefitted from significant improvements to production, safety, and quality.

Enbridge selected Pipeline Enterprise for its ability to capture digital data from all facets of the pipeline's construction, storing everything in one cloud-based database that is readily accessible and searchable. This ensures that turnover is traceable, verifiable, and complete while meeting all applicable legal requirements. This makes it the perfect tool for pipeline construction projects, as it reduces time spent during turnover and commissioning -- resulting in faster in-service time and a quicker return on investment.

Metegrity's Pipeline Enterprise Software Captures Digital Data, Accelerates Production on North America's Largest Pipeline Project

Enbridge utilized the software during the project across nine spreads and nine contractors. Inspectors quickly became familiar with the iPad application and used it for their daily reports, weld inspections, and other specialized reports. Senior field staff used the desktop version to accept, reject, and comment on inspector reports, track production progress, plan next steps, and more.

Metegrity is proud of the accelerated production they have been able to facilitate on projects with Enbridge thus far and looks forward to a continued successful partnership.

14TH PIPELINE TECHNOLOGY CONFERENCE

Europe's Leading Pipeline Conference and Exhibition

18-21 MARCH 2019, ESTREL CONVENTION CENTER, BERLIN, GERMANY

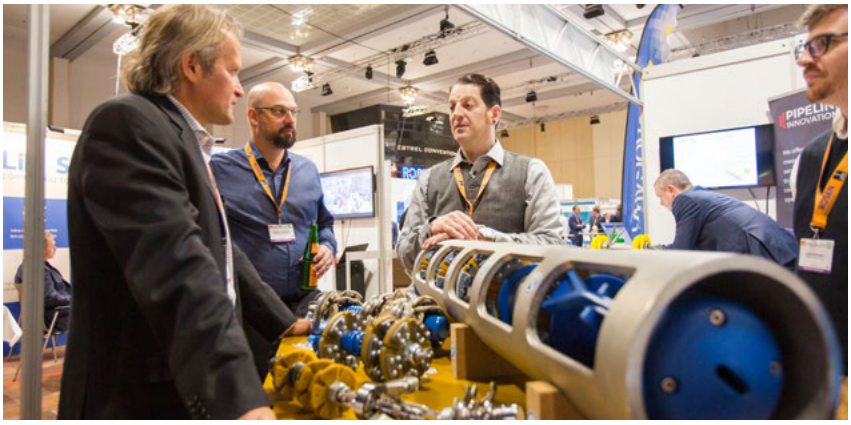
EVENT PREVIEW

800+ DELEGATES | **80+** EXHIBITORS | **50+** DIFFERENT NATIONS

From 18-21 March 2019 Europe's leading conference and exhibition on pipeline systems, the Pipeline Technology Conference, will take place for the 14th time. The core ptc (19-21) will be supplemented with a side conference and a number of seminars, taking place on 18th of march.

ptc 2019 offers again opportunities for operators as well as technology and service providers to exchange latest onshore and offshore technologies and new developments supporting the energy strategies world-wide. More than 800 delegates and 80 exhibitors are expected to participate in the 14th 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 high, medium and low pressure pipeline systems.



70+ Pipeline Operators

17 thematic focuses at ptc 2019

- Construction
- Corrosion Protection
- Digitalization
- Environmental Impact
- Illegal Tapping
- Inline Inspection
- Integrity Management
- Leak Detection
- Maintenance & Repair
- Materials
- Offshore Technologies
- Planning & Design
- Pump & Compressor Stations
- Stress Corrosion Cracking
- Third Party Impact
- Trenchless Technologies
- Valves & Fittings

1 ptc Side Conference
on Public Perception

4 ptc Seminars

- Inspection Technologies for Traditional and Challenging Pipelines
- Inspection of Offshore Pipelines and Risers
- Pipeline Life-cycle Extension Strategies
- Risk Assessment and Management of Pipeline Projects subjected to Geohazards

ptc

14TH PIPELINE TECHNOLOGY CONFERENCE & EXHBITION

EUROPE'S LEADING PIPELINE EVENT

THE ANNUAL GATHERING OF THE INTERNATIONAL PIPELINE COMMUNITY IN THE HEART OF EUROPE

After starting as a small side event of the huge HANNOVER MESSE trade show in 2006, the Pipeline Technology Conference developed into Europe's largest pipeline conference and exhibition. Since 2012 the EITEP Institute organizes the ptc on its own and moved the event to Berlin in 2014.

EXHIBITORS OF PTC 2018:

PROGRAM OVERVIEW

MONDAY, 18 MARCH 2019

PTC SIDE CONFERENCE	PTC SEMINARS
Public Perception	**4 Technical Seminars**

ptc Reception (for invited speakers, exhibitors, comittee members, session chairs and side conference delegates only)

PTC CONFERENCE

TUESDAY, 19 MARCH 2019

Opening / Welcome

Keynote Speech

"Learning from Failures: Moving from 'Failure' Cause to 'Root' Cause"

Plenary Session

"Eurasian Pipeline Forum - Linking East and West"

Panel Discussion

"Digital Transformation and Cyber Security in the Pipeline Industry"

1.1 Inline Inspection	**2.1 Digitalization**	**3.1 Materials**	**4.1 Trenchless Technolgies**	**5.1 Coating**	**6.1 Qualification & Recruitment**

ptc Get-together party with raffle within the exhibition

PTC EXHIBITION

WEDNESDAY, 20 MARCH 2019

1.2 Inline Inspection	**2.2 Pump & Compressor Stations**	**3.2 Leak Detection**	**4.2 Environmental Impact**	**5.2 Coating**	**6.2 Recruiting & Retaining**
1.3 Stress Corrosion Cracking	**2.3 Case Study "TAL Pipeline"**	**3.3 Leak Detection**	**4.3 Construction**	**5.3 Corrosion**	
1.4 Integrity Management	**2.4 Offshore Technologies**	**3.4 Third Party Impact**	**4.4 Planning & Design**	**5.4 Valves & Fittings**	
1.5 Integrity Management	**2.5 Offshore Technologies**	**3.5 Illegal Tapping**	**4.5 Planning & Design**	**5.5 Maintenance & Repair**	

ptc Dinner Invitation "Classic Remise Berlin: A center for vintage cars" (separate registration required)

PTC EXHIBITION

THURSDAY, 21 MARCH 2019

Plenary Session

"Pipelines 2050: From Fossil Fuels to Renewable Fuels?"

Panel Discussion

"Illegal Tapping - Focus Regions, Monitoring and Counter Measures"

Closing Remarks

PTC EXHIBITION

PTC WORKSHOPS	PTC ROUND TABLES
(free access for all delegates)	(free access / for pipeline operators only)

Confirmed Exhibitors as of 04.03.2019

14TH PIPELINE TECHNOLOGY CONFERENCE

Europe's Leading Pipeline Conference and Exhibition

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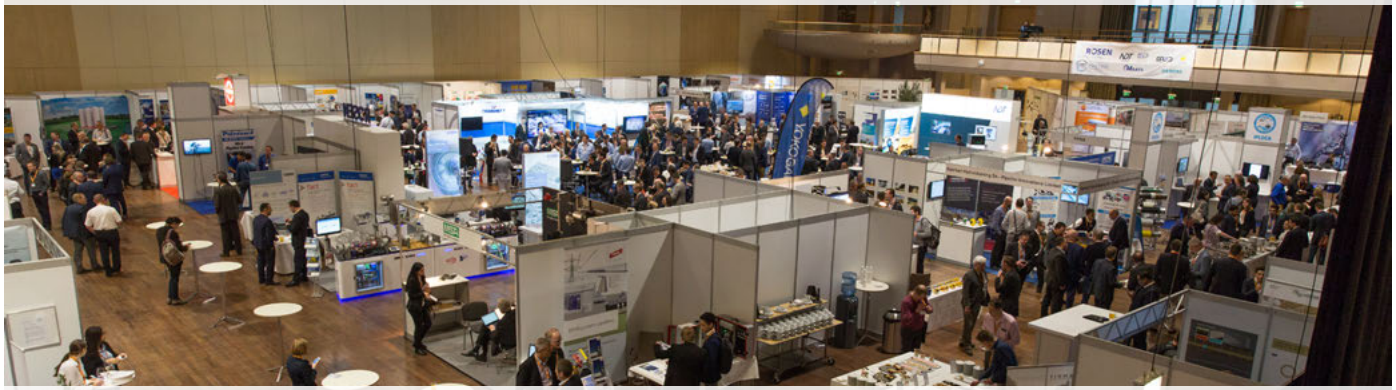
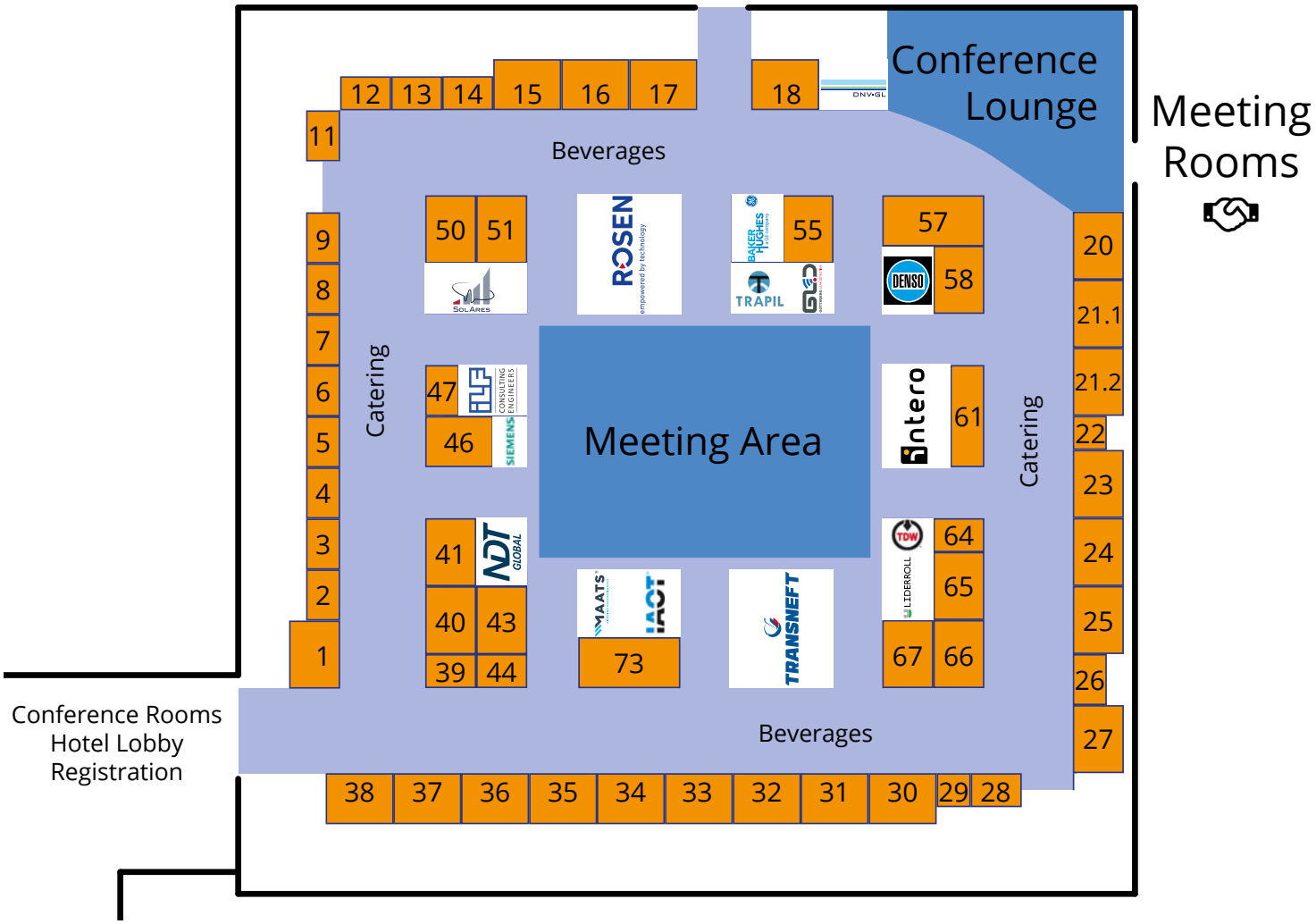


Floor Plan



Diamond Sponsor

ROSEN is a leading privately owned company serving the oil and gas industry with inspection, integrity, and rehabilitation products and services. For over 30 years, ROSEN has provided the industry with advanced inspection and integrity solutions to ensure safe and economical operation of a wide range of assets and facilities. The ROSEN Group operates in more than 100 countries and employs over 2,000 people. Founded by Hermann Rosen in Germany in 1981, ROSEN has been headquartered in Switzerland since 2000. In September 2011, ROSEN celebrated its 30th anniversary.

Today, ROSEN not only serves the oil and gas industry but also provides a wide range of sophisticated and innovative products and system solutions to engineering industries such as aerospace, marine, transportation and security. ROSEN also has the expertise and equipment to inspect utility assets such as telecommunication towers, wind turbines, transmission towers, rail wheels and water distribution systems.

Products & Services

- Pipeline cleaning and inspection services
- Pipeline cleaning tools, accessories and spare parts
- Pipeline rehabilitation services
- Cleaning of tanks
- Plant & terminal inspection (tanks and other structures in refineries, processing plants, tank farms, etc.)
- Inspection of fresh water systems
- Inspection of utility assets such as telecommunication towers, wind turbines, transmission towers, rail wheels and sea-going vessels
- Standard and customized solutions for a wide range of engineering industries (security devices, intelligent plastic solutions, pipe coating)
- Integrity management services and software solutions

Platin Sponsor

Intero Integrity Services is the world's only inspection and industrial services specialist to combine innovative technologies, critical insights, state-of-the-art equipment and advanced data management with a streamlined project approach.

We utilize insightful techniques with innovative inspections and industrial technologies to ensure you have the best solutions for accurate and reliable data at your disposal, enabling you to reduce project time, risk and cost. We make it our business to optimize the workable space of your assets, delivering maximum performance, maximum protection and maximum predictability.

Using innovative industry solutions and expert knowledge, Intero Integrity Services is proud to bring you the very best services, previously provided by A.Hak Industrial Services, in asset inspection, industrial services and data management, supporting operations in all key energy hubs.

Inspection Services
Inline Inspection
Storage Tank Services
Pipeline Integrity Management Services (PIMS)

Industrial Services
Nitrogen Services
Cleaning Services
Pipeline Services

We know the inspection and industrial services solutions you need. We know how to analyze and manage your data to insightful effect. And we know what makes your projects run smoother. In short, we know your space.

Platin Sponsor

Transneft is the world leader in oil transportation, the largest pipeline company in the world and the Russian state operator of oil and petroleum products trunk pipelines.

The company operates over 68,000 km of pipelines, more than 500 pumping stations and 24 million m^3 of storage capacity. Transneft ships about 85% of Russian crude oil and over 25% of the country's light petroleum products. Transneft personnel headcount is 119,000. The company celebrated its 25th anniversary in 2018.

Golden Sponsors

MAATS® PIPELINE PROFESSIONALS

Maats is one of the leading suppliers (rental & sales) of specialized equipment and services to the pipeline industry around the globe. Maats is manufacturer of Maats Pipeline Equipment and authorized global sales representative for new Liebherr Pipeline Equipment.

For both Sales and Rental Maats offers a wide range of new and used high quality equipment for the construction of pipelines of all common diameters (Pipe Layers, Bending Machines, Welding Tractors, additional equipment). The Maats network for sales, rental, support and services covers all continents. With over 30 years experience and a deeply rooted emphasis for service, Maats works closely together with its customers to help them achieve maximum project efficiency and productivity with high performance equipment.

By offering a wide scope of products and services, worldwide support network, engineering, technical expertise, and the ability of full transport organization, Maats provides its customers with the comfort of dealing with a single supply source.

NDT GLOBAL

NDT Global is a leading supplier of ultrasonic pipeline inspection and pipeline integrity management. Its state-of-the art inspection fleet provides the entire in-line inspection service spectrum for onshore and offshore pipelines worldwide. The full range of services includes geometry and deformation inspection, metal loss and crack inspection, defect assessment and fitness-for-purpose investigations.

First run success, best data quality and rapid report delivery are our key benchmarks. A skilled engineering and project management team, complemented by one of the best data analysis teams in the industry, has inspected and analyzed millions of kilometers of pipelines worldwide. The company has offices in Australia, Canada, Germany, Ireland, Mexico, UAE, UK and USA.

DENSO

Over the past century, DENSO Group Germany has built a reputation founded on experience, quality and reliability in corrosion prevention and sealing technology. Just a few years after the company was founded in 1922, DENSO Group Germany revolutionised corrosion prevention across the world with the DENSO®-Tape (Petrolatum-Tape), which was already patented in 1927 as the worldwide first product for the passive corrosion prevention of pipelines. Since then, DENSO Group Germany establishes and guarantees the highest quality standards with technically trend-setting products. Research, development and production take place exclusively in Germany. Today, DENSO is a global group of companies that, in spite of its international reach, still strives to deliver sustainable custom solutions and provide personal service to its customers.

The group's core business consists of the development and production of co-extruded 3-ply PE/Butyl-Tapes, Heat Shrinkable Sleeves, Petrolatum-Tapes & Mastics, Jetty Pile Protection Systems, Polyurethane Coatings and Bitumen profiles. The group's high quality products - made in Germany - are applied in countless rehabilitation projects and new pipeline constructions worldwide. No other company has a longer experience in corrosion prevention for pipelines. For more information please visit the website www.denso.de and be inspired by the innovative product finder.

ILF CONSULTING ENGINEERS

ILF Consulting Engineers is an international engineering and consulting firm with 50 years of experience in the engineering of major industrial and infrastructure projects. The successful completion of complex and challenging projects, requiring truly comprehensive management capability and interdisciplinary engineering expertise, is one of the specific strengths of the ILF Group.

With 2,000 highly qualified employees at more than 40 office locations across five continents, the companies of the ILF Group have a strong regional presence. At the same time, close cooperation within the network of the ILF Group makes it possible to draw on international experts and make use of their special experience, processes, and tools.

With over 6,000 projects successfully completed, the companies of the ILF Group rank among the world's leading engineering firms in their fields of expertise. ILF is active in the following main business areas: Oil & Gas, Energy & Climate Protection, Water & Environment, Transport & Structures

IAOT®

International Association of Oil Transporters (IAOT) is an international voluntary, non-profit, non-governmental organization. It aims to support its Members conducting business in the transport of oil and oil products and to effectively coordinate the efforts of its Members to create the most efficient possible conditions for such activity.

The IAOT wants to promote comprehensive development in the oil and oil products transportation and storage on international, national and regional levels. This includes monitoring, development and implementation of industry-specific regulations, representation of the Members' interests in public authorities, regulatory bodies, professional organizations, NGOs etc., and promoting positive perception of oil and oil products transportation and storage of.

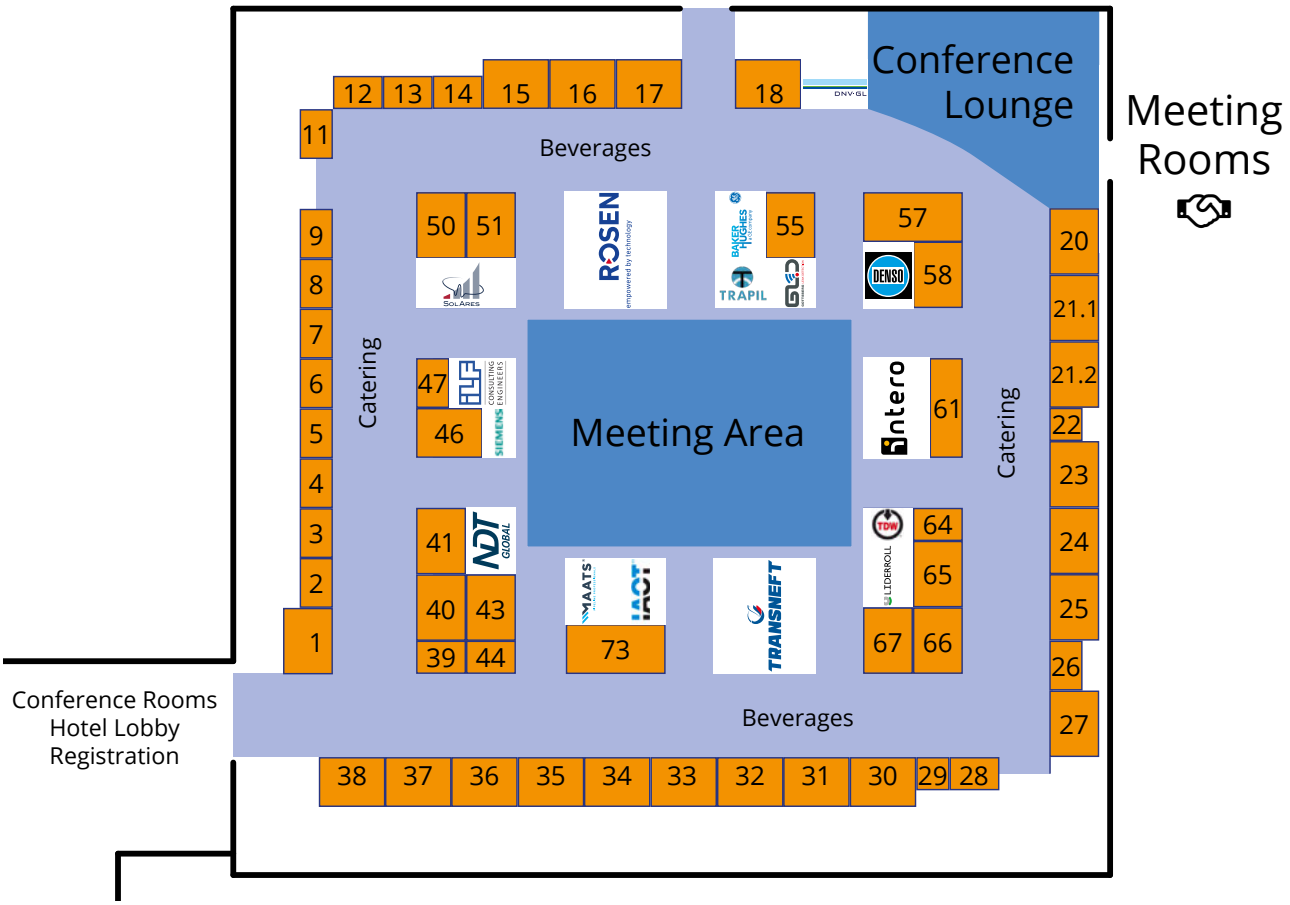
Currently, the IAOT has eight Members: MERO ČR, a.s. (Czech Republic), PJSC "Transneft" (Russia), Transpetrol a.s. (Slovakia), PJSC "Gomeltransneft Druzhba" (Belarus), MOL (Hungary), JSC "KazTransOil" (Kazakhstan), China National Petroleum Corporation (China) and "Ukrtransnafta" PJSC (Ukraine) and one Observer, the Caspian Pipeline

BAKER HUGHES a GE company

Baker Hughes, a GE company (NYSE:BHGE) is the world's first and only fullstream provider of integrated products, services and digital solutions operating in over 120 countries. BHGE helps midstream operators confidently manage their assets, partnering to deliver technology, solutions and expertise for smarter ways of working.

The mutual goal – safe operations, asset integrity and enhanced profitability. BHGE's footprint in the pipeline space includes a unique portfolio of products and services.

- Our advanced pipeline inspection technologies, integrity engineering expertise and powerful data management software help to drive enhanced pipeline safety.
- A range of extensive pre commissioning and maintenance services help enable event free start up, improve efficiency and maximize throughput.
- Our world class rotating equipment, including the NovaLT gas turbine family and compression solutions offer proven reliability, exceptional availability and optimal performance in any environmental conditions.



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TRAPIL With more than 65 year-experience as a pipeline operator, TRAPIL's core business is transporting refined petroleum products. It currently operates three multi-product pipeline networks in France; and owns one to carry more than 35 million tons of petroleum products between refineries, port facilities and depots near major French cities. To address the immense complexity of its operated networks, Trapil is constantly developing innovative new solutions, which are now offered to pipeline users seeking to upgrade their practices. Trapil's broad array of services is built around its major domains of expertise encompassing Engineering, in line Inspection, Integrity management and Product Quality.

GOTTSBERG LEAK DETECTION GOTTSBERG Leak Detection GmbH&Co.KG is a family owned developer and manufacturer of one of the technical leading products in the market of ultrasonic leak detection pigs for pipelines. Its aim is to provide affordable state of technology products that are easy to handle and absolutely reliable in their performance for the sales market as well as for service offers. With its specialists GOTTSBERG Leak Detection can look back at nearly 40 years of experience in the field of pipeline integrity.

TDW T. D. Williamson, Inc., the world's most recognized name in pipeline equipment and services, delivers safe integrity solutions for onshore and offshore applications.

TDW's expertise provides hot tapping & plugging, pipeline cleaning, geometry & MFL inspection, pigging and non-tethered plugging pig technology services for any pressurized pipeline system, anywhere in the world.

SOLARES SolAres, a joint venture between Solgeo and Aresys, is the supplier of e-vpms®: Eni's innovative technology for Pipeline Leak Detection and Pipeline Integrity Monitoring. Already deployed worldwide on over 1300km of pipelines, the technology proved to dramatically reduce the number of Third Party Interferences and their economic and reputational impacts. The technology, after the installation of a minimal set of non-invasive sensors on existing derivations, elaborates in real-time the vibroacoustic waves propagating inside the pipeline. The system is able to detect and precisely localize events as leaks and impacts occurring on the pipeline, with excellent reliability, precision and response time.

DNV·GL Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their businesses. We are the leading technical advisor within the pipeline industry, providing state-of-the-art services and software to comply, manage risk and improve asset performance. Over the years, DNV GL has created a series of internationally recognized standards, service specifications and recommended practices together with the industry. Our first pipeline code was issued in 1976 and has achieved global recognition, winning prestigious industry awards. Currently around 65% of all new projects globally are designed to it.

LIDERROLL A winner of ASME's Global Pipeline Award, Liderroll is the proven worldwide leader in the installation of multiple large-diameter pipelines inside tunnels. To date, Liderroll is the only company to have completed a 5+ kilometer in-tunnel, multiple pipeline installation. Liderroll designs and manufactures its patented high-performance structural supports for pipelines not only for tunnels but also for marine terminals and refineries.

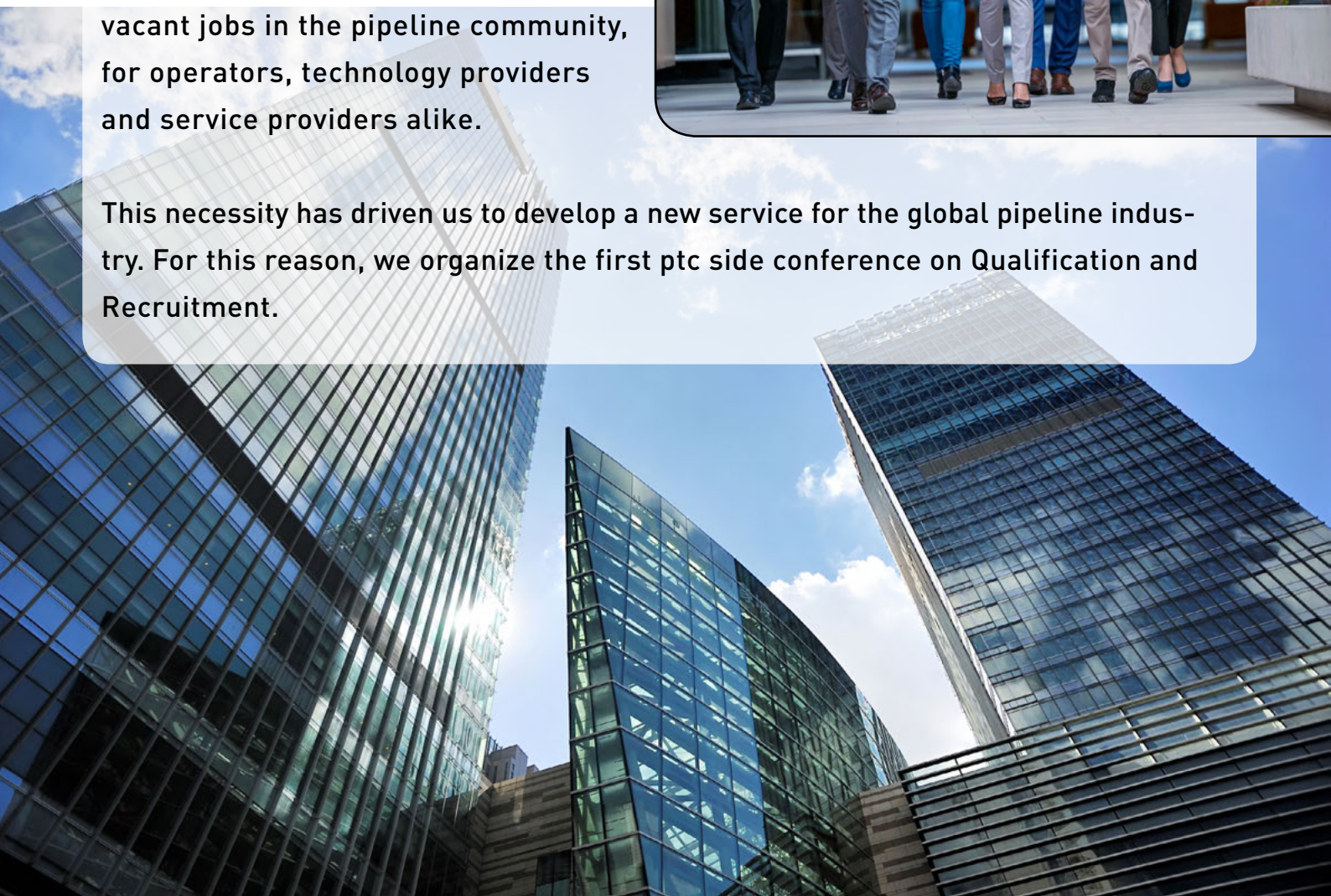
JOB & CAREER MARKET

YOUR OPPORTUNITY TO ATTRACT PROFESSIONALS AND HIGH POTENTIALS

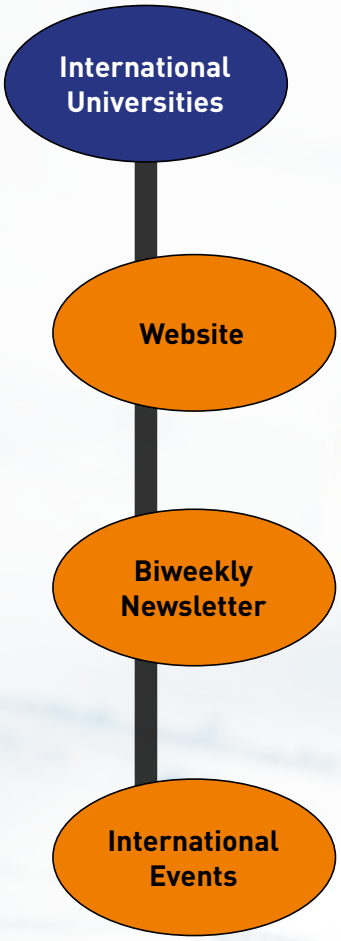
The international pipeline community is in need of additional personnel.

We need more experienced professionals, but we also need young graduates to join our ranks. Despite attractive working conditions, many companies encounter problems while they are reaching out to potential recruits. There are many competing industry sectors who are also in need of high potentials. This results in many vacant jobs in the pipeline community, for operators, technology providers and service providers alike.

This necessity has driven us to develop a new service for the global pipeline industry. For this reason, we organize the first ptc side conference on Qualification and Recruitment.



ONE SERVICE - MULTIPLE CHANNELS



Offensive approach: We push forward and generate attention to our career market directly at the universities. We also collect CVs from international graduates and experts and forward it directly to you.

Continuous promotion : Your vacancies are published on the Pipeline Technology Journal (ptj) website. In Addition, the ptj contains your vacancies too.

Dead on target: We send your vacancies or your company profile to our database of 50,000 international pipeline professionals.

Physical appearance: The job & career market has an individual booth during all EITEP events.

Questions?

Please contact Mr. Admir Celovic for further information and booking requests.

celovic@eitep.de
+49 / 511 / 90992-20

You get:

The most cost-effective support to your recruitment efforts available to the market

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LIN SCAN
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NDT Global
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www.ndt-global.com

Pipesurvey International
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Liwacom
Germany
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MSA
Germany
www.MSAsafety.com/detection

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OptaSense
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Pergam Suisse
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PSI Software
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sebaKMT
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www.sebakmt.com

SolAres (Solgeo / Aresys)
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www.solaresweb.com

VEGASE
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Monitoring

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Krohne Messtechnik
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PHOENIX CONTACT
Germany
www.phoenixcontact.de/prozess

SolSpec
United States
www.solspec.solutions

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Transneft
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YPPE - Young Pipeline Professionals Europe
International

Pump and Compressor Stations

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The Netherlands
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Repair

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www.cittech.com

Clock Spring NRI
United States
www.clockspring.com

RAM-100
United States
www.ram100intl.com

T.D. Williamson
United States
www.tdwilliamson.com

Research & Development

Pipeline Transport Institute (PTI LLC)
Russia
www.en.niitn.transneft.ru

Safety 1/2

DEHN & SÖHNE
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www.dehn-international.com/en

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www.hima.de

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Franken Plastik
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Surface Preparation

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Germany
www.monti.de

Trenchless Technologies

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GSTT - German Society for Trenchless Technology
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Germany
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AUMA
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www.auma.com

Zwick Armaturen
Germany
www.zwick-armaturen.de

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ptc Side Conferences Public Perception	**18 March 2019**	**Berlin, Germany**
14th Pipeline Technology Conference (ptc)	**19 - 21 March 2019**	**Berlin, Germany**
LNG 2019 Shanghai	1 - 5 April 2019	Shanghai, China
Commercial UAV Expo Europe	08 April 2019	Amsterdam, Netherlands
16th Moscow International Oil and Gas Exhibition MIOGE 2019	23 - 26 April 2019	Moscow, Russia
34th International Scientific & Expert Meeting of Gas Professionals	8 - 10 May 2019	Opatija, Croatia
Global Petroleum Show 2019	11 - 13 June 2019	Calgary, Canada
UESI Pipelines 2019 Conference	21 July 2019	Nashville, Tennessee, USA
Comm UAV Americas	28 - 30 October 2019	Las Vegas, USA
15th Pipeline Technology Conference	**30 March - 2 April 2020**	**Berlin, Germany**

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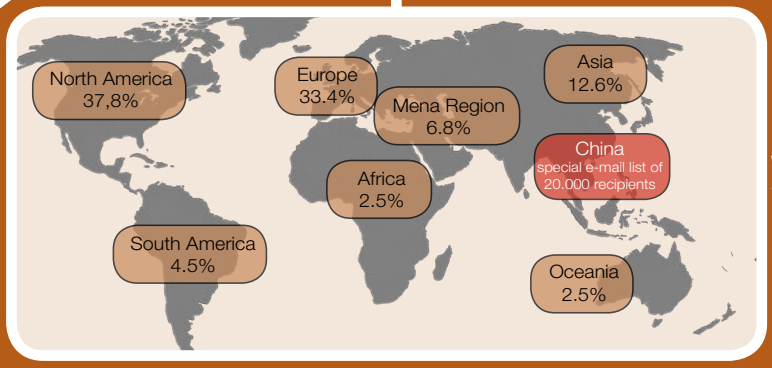

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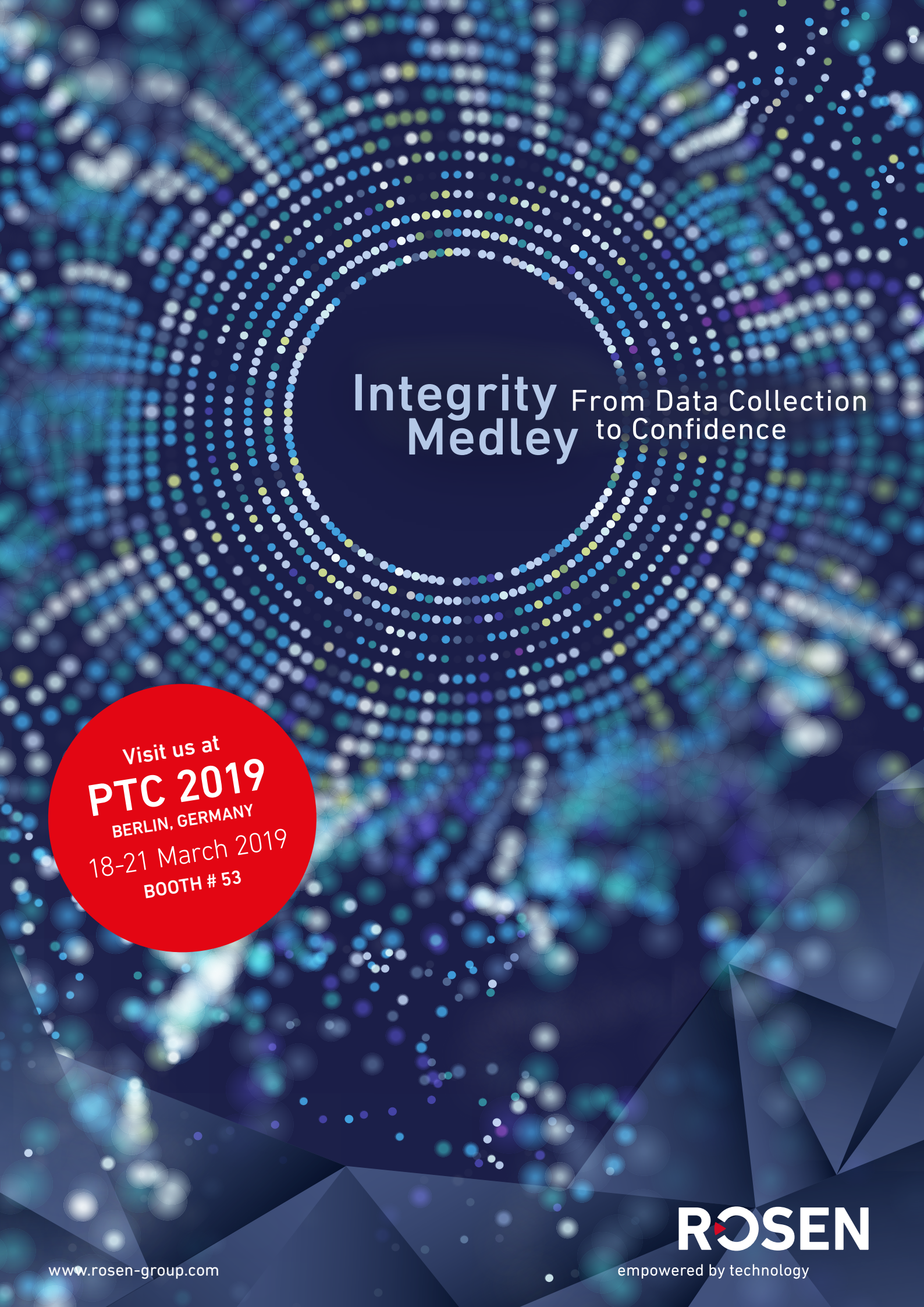
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