May 2014

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ptj

Pipeline Technology Journal

Industry & Practice

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- Personnel and administrative developments

Research / Development / Technology

- Sustainable Rehabilitation
- The Linear Risk Integral (LRI) approach in pipeline QRA
- Turkmen Gas to Turkey & EU
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Conferences / Seminars / Exhibitions

- Upcoming International events 2014
- Report: Pipeline Technology Seminar Middle East
- Pipeline Technology Conference, ptc, moves to Berlin

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Dr. Klaus Ritter, President,
EITEP Institute

Editorial

Dear readers,

as in our second issue underlined, it has never been more important to ensure the safety and reliability of pipelines. Hence with the increasing of the natural gas production, safe and secure energy transport is basic for all economies in the world. Safety, reliability, integrity and economics of oil & gas transported via pipelines are key parameters for the acceptance of all stakeholders involved. Natural gas will also support renewable energies in the future. For diversification of gas resources the transport of LNG will also increase compared to import by pipeline gas. Around 25,000 km of pipelines have been laid annually worldwide till now. These lines are being laid to cover the needs of industry and households in regions that lack sufficient resources of their own. This will go on for quite a while yet, because the hunger for energy is still a long way from being sated. In the rapidly developing regions of the world such as India, China and South America, the demand for energy and so for pipelines has not been dampened. In North America, Europe, Russia, etc., it's further internal networking that's involved. For natural gas, however, the signs are pointing to a reversal in Europe:

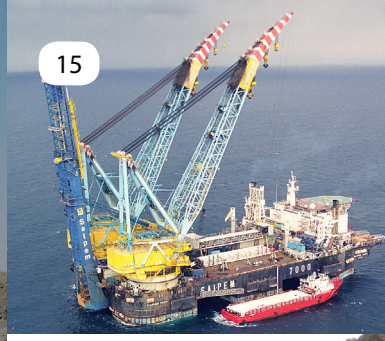
- The North American market, because of shale gas coming on stream, has become so saturated that the prices have plunged, and it remains to be seen whether the American producers can reach the European market in the form of LNG.
- Increased production of shale gas may also be expected in Europe.
- The Arab Spring, to endure, must have some economic successes. This can only happen if they can sell their own resources, which lie off the coast of Egypt and in the south of Tunisia and Libya, to Europe.
- The powerful, existing gas flows from Russia to Central and Western Europe are being complemented by Nord Stream and soon by South Stream.
- The expansion of renewable energies reduces the need for fossil fuels.

Europe is incapable to attain self-support, consequently transport infrastructure will be significant to guarantee energy security. The European gas market is a buyer's market, and the consumers have all the advantages. Extension of the networks, however, is being promoted. The production of natural gas will consequently increase the possibility for pipeline construction, as transportation is needed from the shale basins to point of sale. Thus the pipeline market is continuing to boom worldwide.

As in our international Pipeline Technology Conference ptc, as well as in our Pipeline Technology Journal ptj we hereby continue discussing latest developments in pipeline monitoring and security technology in order to meet the challenges of today's challenging environment and economy. Research and development can best be transported to the professional public via the Pipeline Technology Journal (ptj) and the Pipeline Technology Conference (ptc).

Therefore please inform us further about your latest scientific results and developments. Case studies of new ideas and projects are also welcome.

Yours Sincerely,



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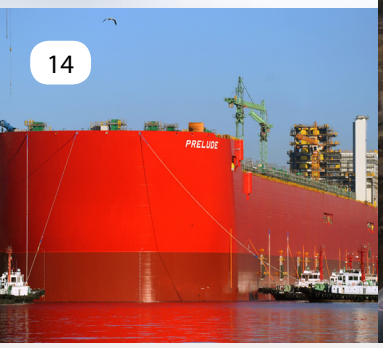

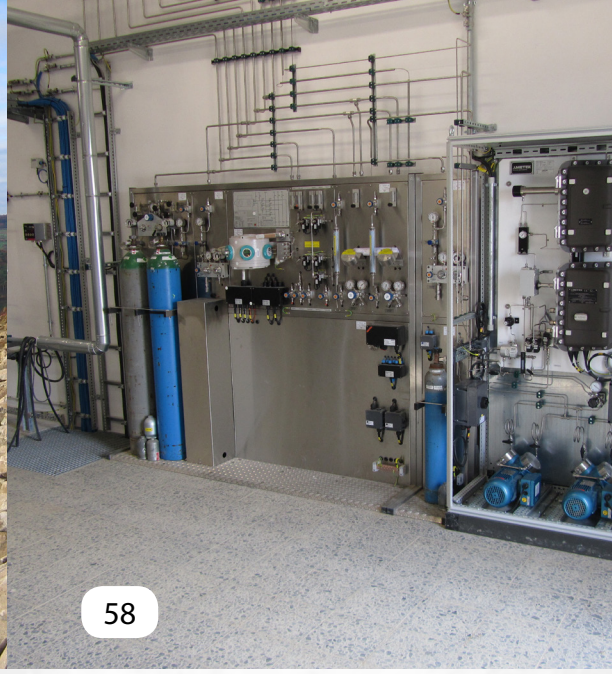

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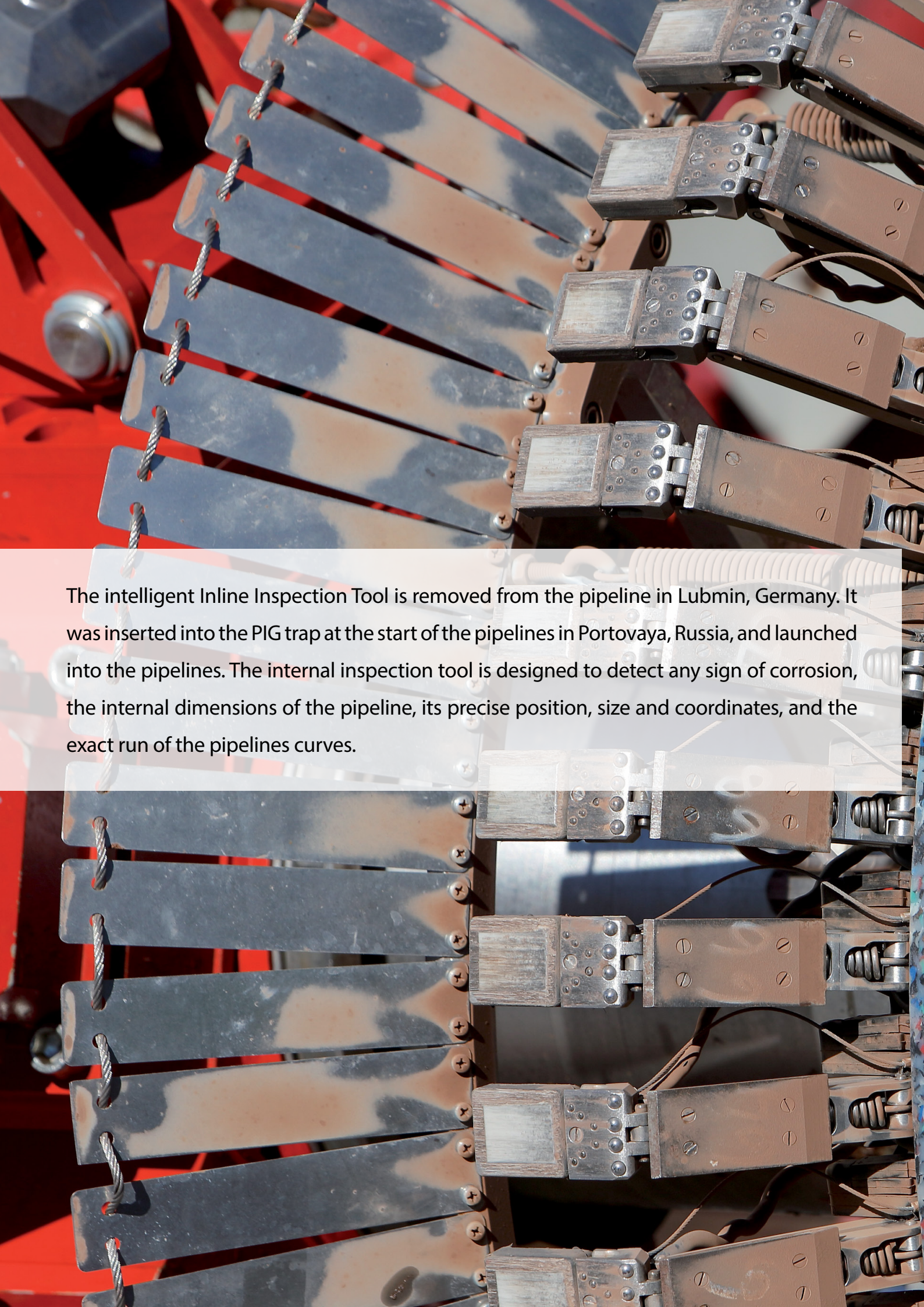
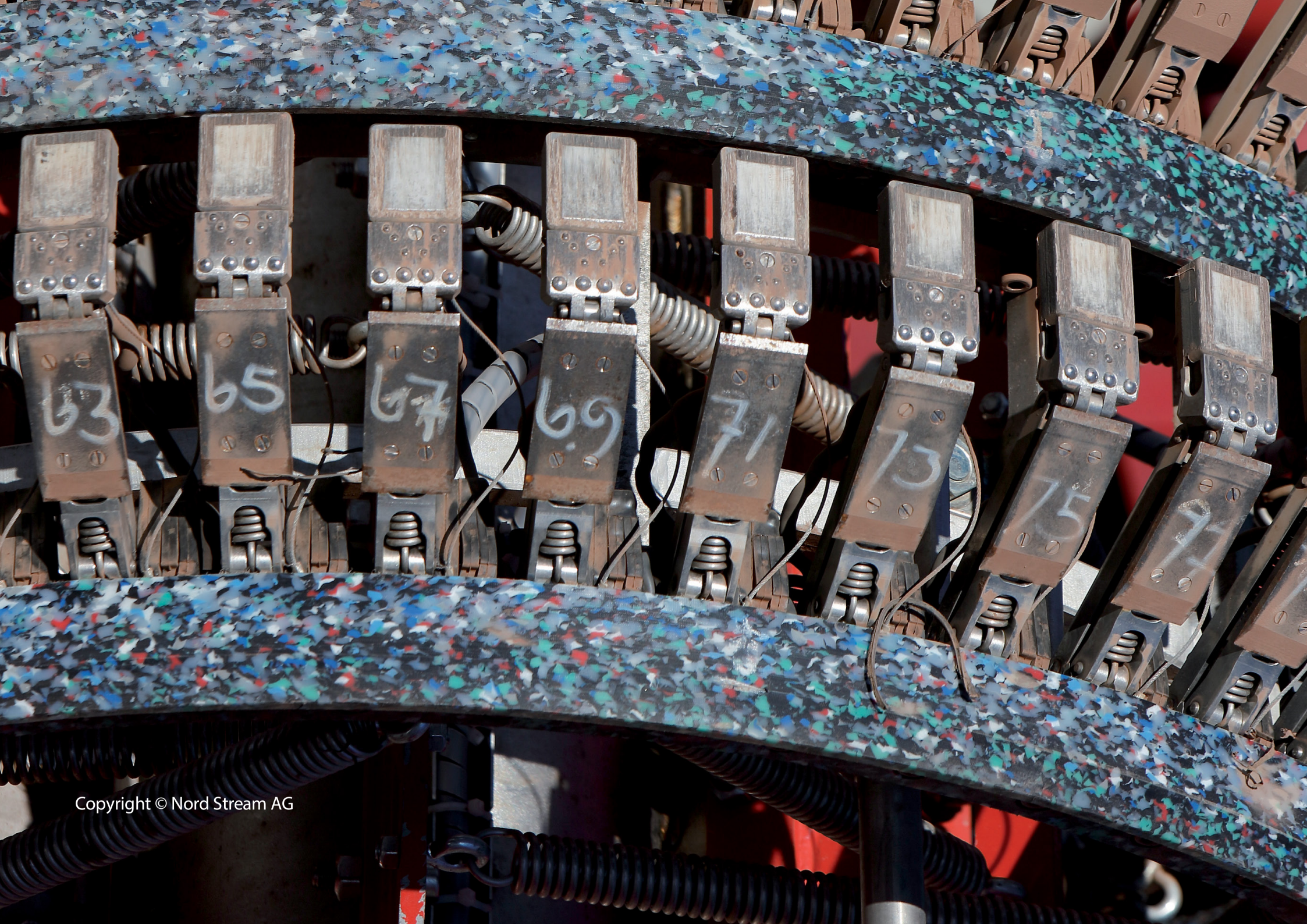
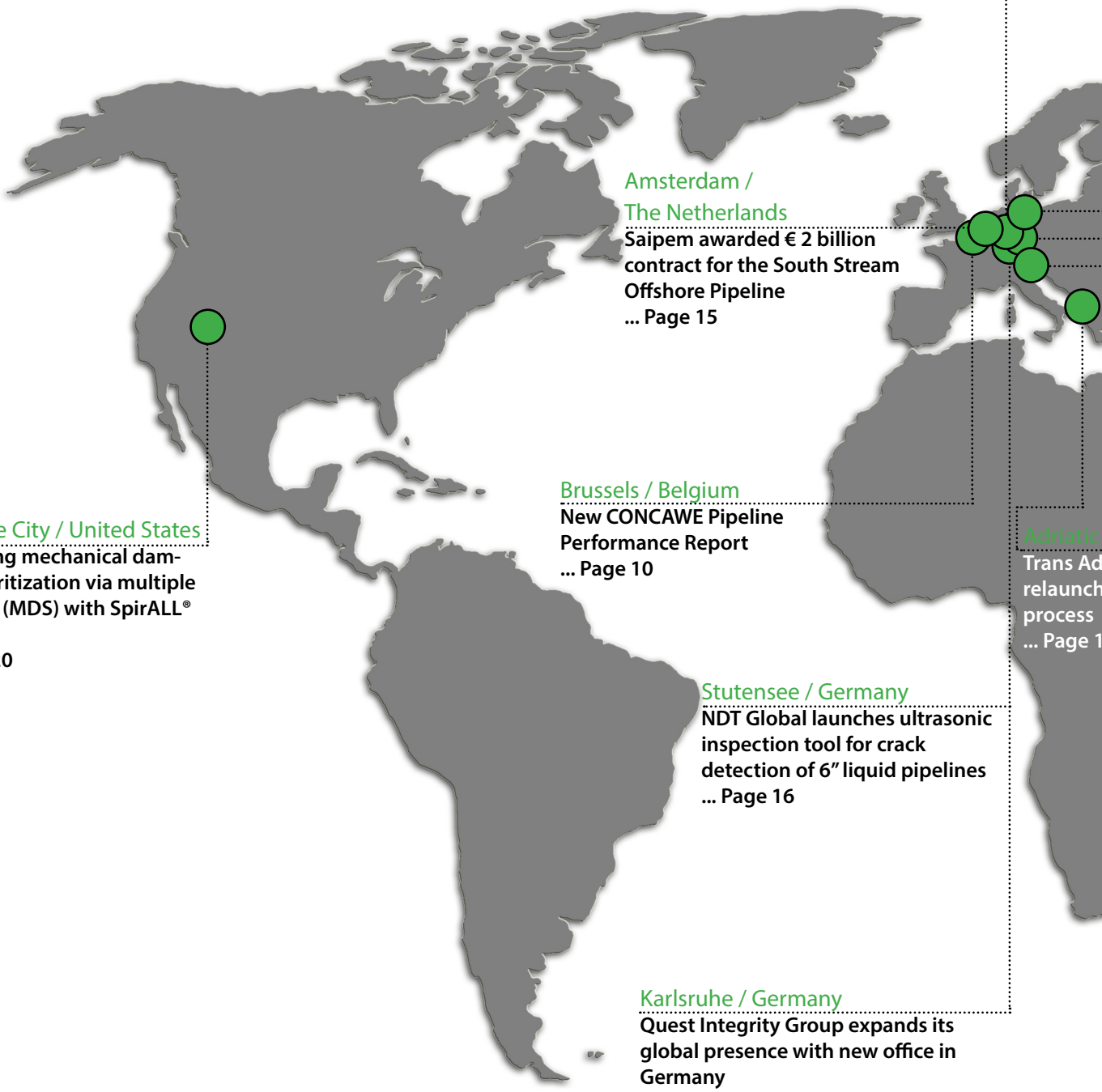


The intelligent Inline Inspection Tool is removed from the pipeline in Lubmin, Germany. It was inserted into the PIG trap at the start of the pipelines in Portovaya, Russia, and launched into the pipelines. The internal inspection tool is designed to detect any sign of corrosion, the internal dimensions of the pipeline, its precise position, size and coordinates, and the exact run of the pipelines curves.





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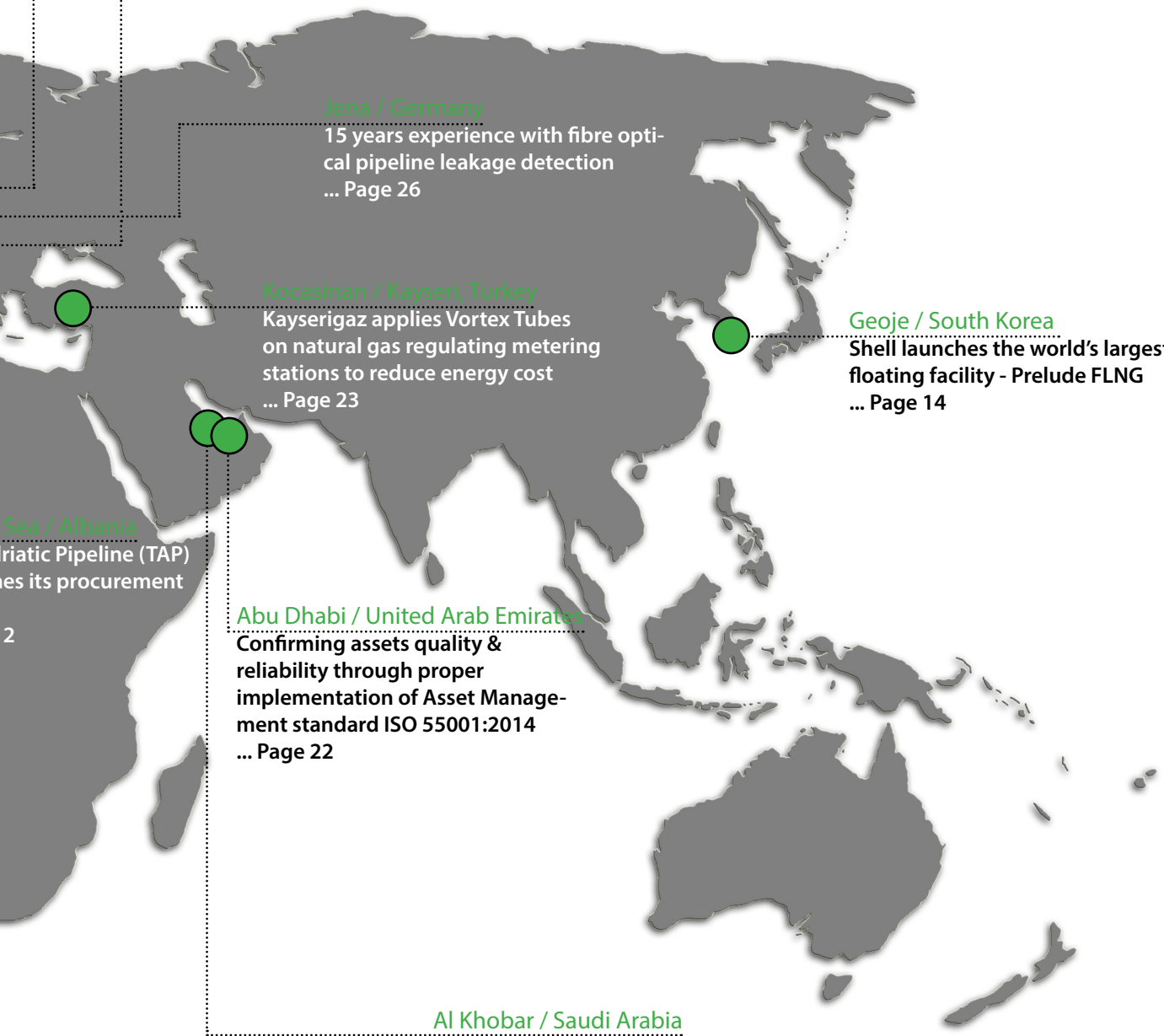

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New CONCAWE Pipeline Performance Report

CONCAWE, having collected 42 years of spill incident data on European cross-country oil and petroleum product pipelines, has published its report "Performance of European cross-country oil pipelines - Statistical summary of reported spillages in 2012 and since 1971". This short article summarises the main finding presented in this report (CONCAWE 2013). CONCAWE has collected 42 years of spill incident data on European cross-country oil pipelines with particular regard to spillages volume, clean-up and recovery, environmental consequences and causes of the incidents. The results have been published in annual reports since 1971. This report covers the performance of these pipelines in 2012 and provides a full historical perspective since 1971. The 79 member companies and agencies operating oil pipelines in Europe currently provide data for the CONCAWE annual survey. For 2012 information was received from 71 operators representing over 156 pipeline systems and a combined length of 36,251 km, a little more than the 2011 inventory. 8 operators did not report and, although there have been no public reports of spillage incidents, they have not been included in the statistics. The total reported volume transported in 2012 was 701 Mm3 of crude oil and refined products, approximately 4% less than in 2011. Total traffic volume in 2012 was estimated at 115x109 m3.km. 12 spillage incidents were reported in 2012, corresponding to 0.33 spillages per 1000 km of line, above the 5-year average of 0.22 and below the long-term running average of 0.51, which has been steadily decreasing over the years from a value of 1.2 in the mid '70s. There were no reported fires, fatalities or injuries connected with these spills. (Figure 1). Of the 12 reported incidents in 2012, 8 were directly caused by third party activities (2 of which related to theft or vandalism), three to corrosion (one internal and two external) and one mechanical (design and materials). Over the long term, third party activities remain the main cause of spillage incidents. Theft attempts have caused a total of 20 spillage incidents between 1971 and 2012, 4 of which (20%) were in the past two reporting years. Mechanical failure is the second largest cause of spillage. After great progress during the first 20 years, the frequency of mechanical failures appeared to be on a slightly upward trend over the last decade, although figures from recent years are again low. The 2012 gross spillage volume was 371m3 or 10 m3 per 1000 km of pipeline compared to the long-term average of 73 m3 per 1000 km of pipeline. About 45% of that volume was recovered. In-line inspections were at a sustained level in 2012. A record total of 119 sections covering a total of 13,050 km were inspected by at least one type of inspection pig. Most inspection programmes involved the running of more than one type of pig in the same section, so that the total actual length inspected was less at 7119 km (20% of the inventory) (Figure 2).

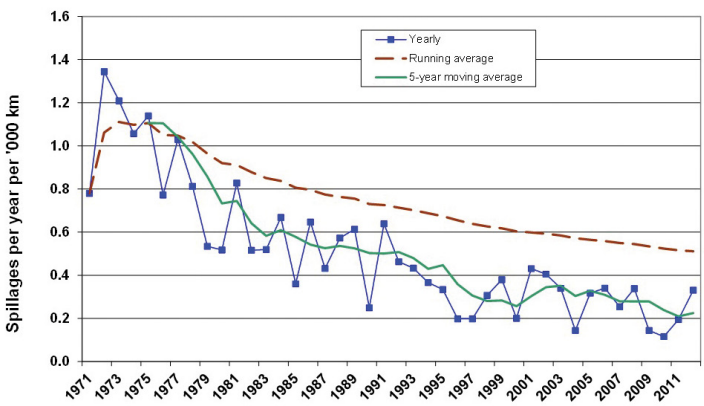

Figure 1: Spill incident frequency per 100 km of pipeline 1971 - 2012

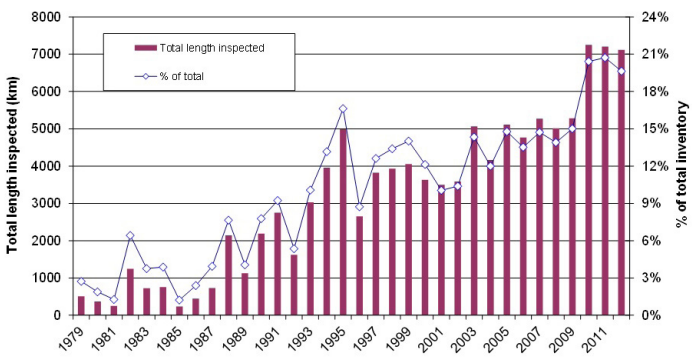

Figure 2: Historic evolution of in-line pipeline inspections 1971 - 2012

Most pipeline systems were built in the '60s and '70s. Whereas, in 1971, 70% of the inventory was 10 years old or less, by 2012 only 4.8% was 10 years old or less and 58% was over 40 years old. However, this has not led to an increase in spillages (Figure 2).

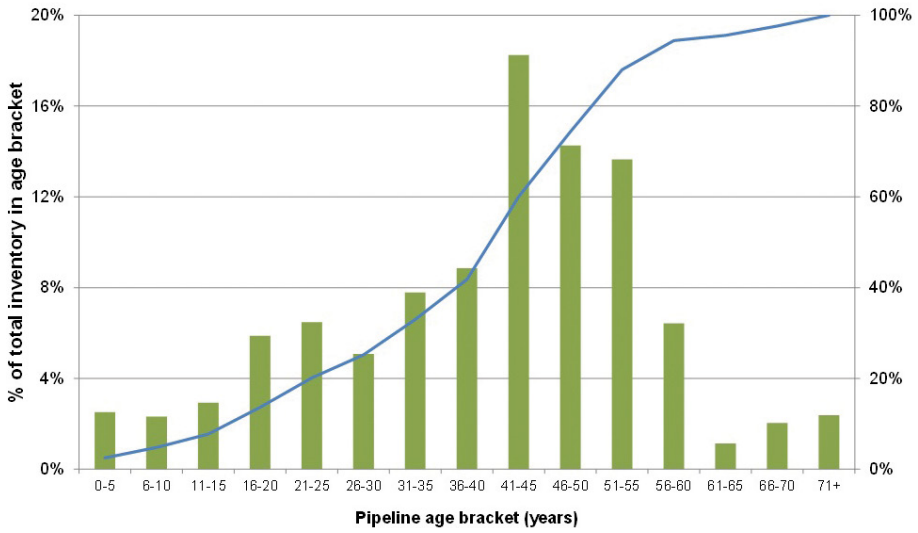

Figure 3: The age-profile of the CONCAWE crude oil and product pipeline inventory

Overall, based on the CONCAWE Incident database and reports, there is no evidence that the ageing of the pipeline system implies a greater risk of spillage. The development and use of new techniques, such as internal inspection with inspection pigs, hold out the prospect that pipelines can continue reliable operations for the foreseeable future.

CONCAWE pipeline statistics, in particular those covering the mechanical and corrosion incidents, will continue to be used to monitor performance. At over 36,000 km the inventory covered currently includes the vast majority of such pipelines in Europe, transport ing close to 700 million m3 per year of crude oil and oil products. This report covers the performance of these pipelines in 2012 and a full historical per spective since 1971. The performance over the whole 42 years is analysed in various ways, including gross and net spillage volumes, and spillage causes grouped into five main categories: mechanical failure, operational, corrosion, natural hazard and third party. The rate of inspections by in-line tools (inspection pigs) is also reported. 12 spillage incidents were reported in 2012, corresponding to 0.33 spillages per 1000 km of line, above the 5-year average of 0.22 and below the long-term running average of 0.51, which has been steadily decreasing over the years from a value of 1.2 in the mid-70s. There were no fires, fatalities or injuries connected with these spills. 1 incident was due to mechanical failure, 3 to corrosion, and 8 were connected to third party activities, 2 of which malicious. Over the long term, third party activities remain the main cause of spillage incidents although mechanical failures have increased in recent years, a trend that needs to be scrutinised in years to come.

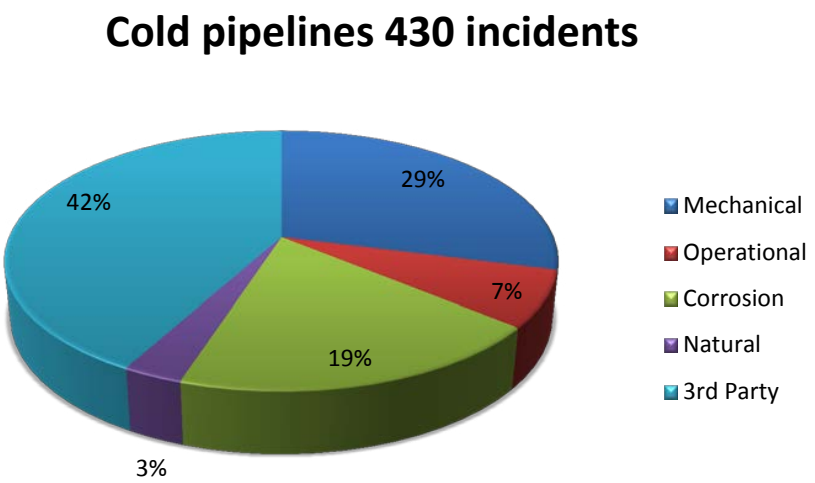

Figure 4: Main causes of the spill incidents

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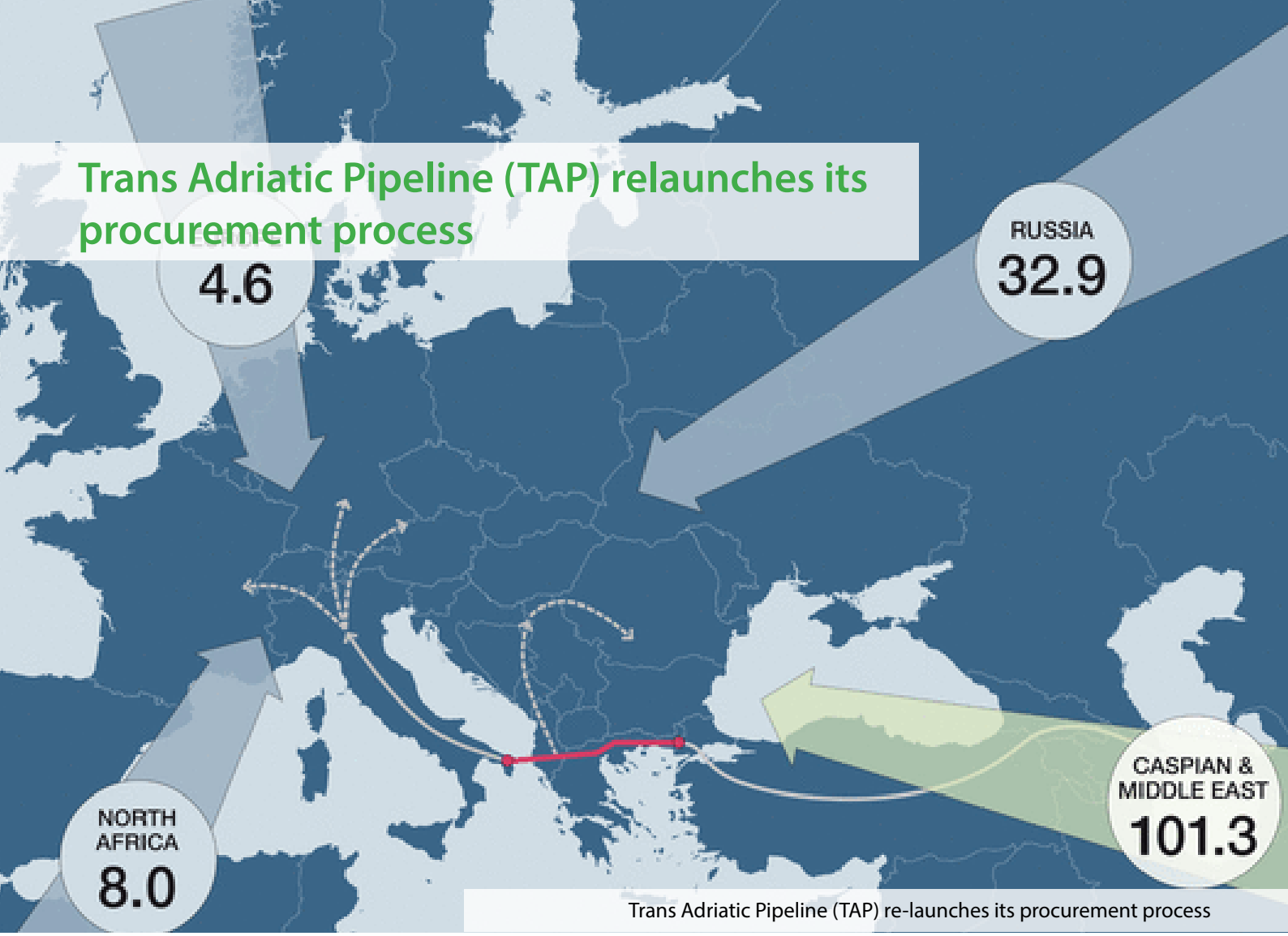
References

CONCAWE (2013) Performance of European cross-country oil pipelines - Statistical summary of reported spillages in 2012 and since 1971. CONCAWE Report 12/13, Brussels

This report can be downloaded free of charges from the publications on the CONCAWE website: www.concawe.org

Trans Adriatic Pipeline (TAP) relaunches its procurement process



Trans Adriatic Pipeline (TAP) re-launches its procurement process

TAP has taken the decision to re-launch its procurement process, following a review of its strategy and schedule. TAP will therefore initiate new pre-qualifications for goods and services that the natural gas pipeline project requires. The revised pre-qualification process should ensure maximum opportunity for national and international suppliers to take part in this important and strategic project. TAP will re-launch the process to procure goods and services in the following main areas:

Engineering Procurement Construction (EPC): The majority of suppliers who will be requested to pre-qualify this year will be for Engineering Procurement Construction services. These include for example: onshore and offshore pipeline construction services, compressor stations and Pipeline Receiving Terminal construction.

Supply Contracts: These include the procurement of steel pipes, SCADA systems and large diameter pipeline valves. These contracts will be managed by TAP directly.

TAP intends to publish notices in the Official Journal of the EU - The EU Gazette for each of the contracts. Companies with the relevant experience can apply. The first Contract Notice can be found in the EU Gazette for pre-qualification of potential suppliers for construction of Albanian Access Roads and Bridges. Subsequent Contract Notices will appear over the next months. All companies with relevant experience – including those that applied previously – are encouraged to participate in the newrounds of pre-qualification.

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OMV and Gazprom strengthen partnership

The CEOs of Gazprom and OMV, Alexei Miller and Gerhard Roiss, met Tuesday at OMV headoffice to discuss the challenging current market environment for gas. Apart of the ongoing gas supply contract negotiations, the parties also discussed the current political situation, making it clear that Austria's gas supply is a top priority. Despite the actual situation the import levels for Russian gas are according to the seasonal habits. The partners also discussed optional alternative supply routes for Russian gas for example via "Nord Stream" through OPAL to the center of Europe.

Gazprom CEO Alexei Miller: "We appreciate the ongoing dialogue with business partners like OMV to secure the supply of gas. Gazprom was praised as a reliable supplier contributing significantly to Austria's energy security. Furthermore it was pointed out that the current geopolitical situation proves the importance of alternative routes for Russian gas supplies to European consumers."

OMV CEO Gerhard Roiss: "In Europe we live in a society with shared resources, products and services. With this in mind, I believe that the economic integration of Europe and our partners in Russia is the way to preserve the stability of our continent. Today's meeting underlines our partnership with Gazprom, which has been in place for more than 50 years."

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Alexei Miller (CEO Gazprom) and Gerhard Roiss (CEO OMV)

Shell launches the world's largest floating facility - Prelude FLNG

The 488-metre-long hull of Shell's Prelude floating liquefied natural gas (FLNG) facility has been floated out of the dry dock at the Samsung Heavy Industries (SHI) yard in Geoje, South Korea, where the facility is currently under construction. Once complete, Prelude FLNG will be the largest floating facility ever built. It will unlock new energy resources offshore and produce approximately 3.6 million tonnes of liquefied natural gas (LNG) per annum to meet growing demand. "Making FLNG a reality is no simple feat," said Matthias Bichsel, Shell Projects & Technology Director. "A project of this complexity – both in size and ingenuity – harnesses the best of engineering, design, manufacturing and supply chain expertise from around the world. Getting to this stage of construction, given that we only cut the first steel a year ago, is down to the expert team we have ensuring that the project's critical dimensions of safety, quality, cost and schedule are delivered." FLNG will allow Shell to produce natural gas at sea, turn it into liquefied natural gas and then transfer it directly to the ships that will transport it to customers. It will enable the development of gas resources ranging from clusters of smaller more remote fields to potentially larger fields via multiple facilities where, for a range of reasons, an onshore development is not viable. This can mean faster, cheaper, more flexible development and deployment strategies for resources that were previously uneconomic, or constrained by technical or other risks. Prelude FLNG is the first deployment of Shell's FLNG technology and will operate in a remote basin around 475 kilometres northeast of Broome, Western Australia for around 25 years. The facility will remain onsite during all weather events, having been designed to withstand a category 5 cyclone. Shell is the operator of Prelude FLNG in joint venture with INPEX (17.5%), KOGAS (10%) and OPIC (5%), working with long-term strategic partners Technip and Samsung Heavy Industries (the Technip Samsung Consortium).

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Prelude FLNG - Hull Float Launch

Saipem awarded € 2 billion contract for the South Stream Offshore Pipeline

Saipem 7000 pipe-laying vessel

End of last week in Amsterdam (Netherlands) Oleg Aksyutin, Chief Executive Officer of South Stream Transport B.V. and Stefano Bianchi, Senior Vice President of Saipem entered into contracts for constructing the first of the four offshore lines of the South Stream gas pipeline. According to the signed contracts worth around EUR 2 billion, Saipem will generate the project documentation, build the first offshore line of the South Stream gas pipeline as well as erect process facilities in the shore crossing areas as well as construct the landfalls. Pipes will be welded together on board a special pipe-laying vessel and then laid in a proper position on the seabed at a depth of up to 2,200 meters. The South Stream gas pipeline will be laid by two pipe-laying vessels of Saipem: Castoro Sei, an S-lay vessel suitable for both shallow and deep waters and Saipem 7000, a J-lay vessel that constructed the Blue Stream gas pipeline in the Black Sea in the early 2000s. For the shore crossings, four micro-tunnels will be built on both the Russian and the Bulgarian side. This technology will allow preserving the Russian and Bulgarian coastlines. Preparations for micro-tunneling operations will start in June 2014 Offshore construction will start in autumn 2014. The construction of the first offshore line will last until the third quarter of 2015. At the end of the same year the first line will be commissioned.

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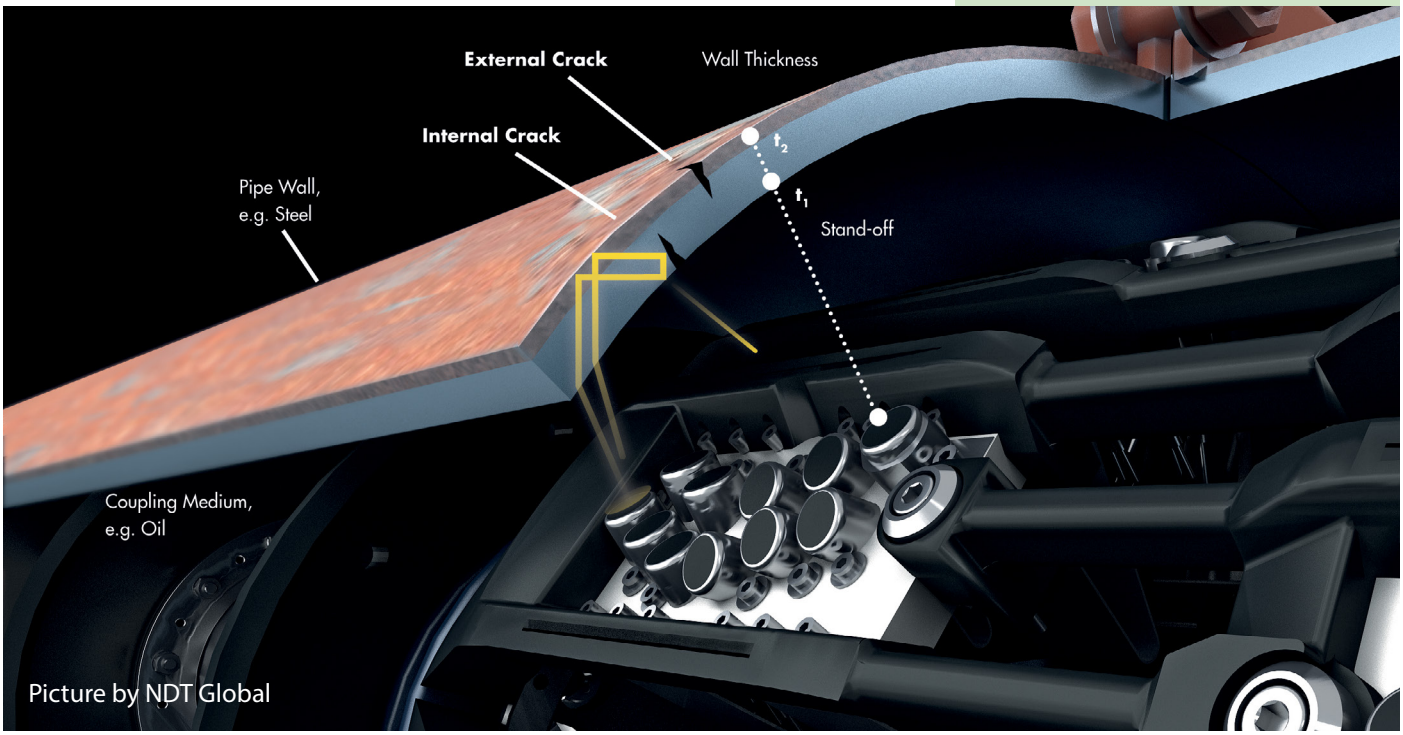
NDT Global launches ultrasonic inspection tool for crack detection of 6" liquid pipelines

NDT Global, a leading supplier of ultrasonic pipeline inspection and integrity services, announces the commercial availability of LineExplorer UC crack detection ILI (Intelligent Inline Inspection) tool for 6-inch pipelines. The new ultrasonic ILI tool detects and sizes axial cracks and crack-like features such as fatigue cracks, stress corrosion cracking (SCC) or weld cracks. Six-inch size pipelines are predominantly used for the transportation of refined products as well as crude oil over relatively short distances. The tool handles inspection distances up to 80 km and has 1.5D bend capability. Its in-house designed sensor carrier is equipped with 144 newly developed crack inspection sensors tosecure optimum inspection data quality. Cracks and crack-like features can appear during manufacturing, construction and operational life of a pipeline. Inline Inspection and subsequent data analysis ensure early detection of cracks thus preventing pipeline failure which happens when the crack dimension reaches a material-specific critical size. NDT Global's new 6-inch ultrasonic tool is a result of the company's tool expansion program and reflects the growing demand for enhanced inline inspection data accuracy and integrity services by pipeline operators and owners.

About NDT

NDT Global is a leading supplier of ultrasonic pipeline inspection and pipeline integrity management. The company counts about 500 specialists based in Germany, the US, Canada, Mexico, Russia, UAE, Malaysia and Singapore. Its inline inspection fleet provides the entire inspection service spectrum for onshore and offshore pipelines worldwide. A skilled engineering and project management team, complemented by the best data analysis team in the industry, has inspected and analyzed millions of kilometers of pipelines worldwide.



Picture by NDT Global

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Quest Integrity Group expands its global presence with new office in Germany

Quest Integrity Group, a supplier in the development and delivery of advanced inspection and engineering assessment services and software products, recently announced the opening of a new office in Karlsruhe, Germany. The new office, strategically located to better serve the companies growing European client base, will support the full range of Quest Integrity services to the pipeline, refining, chemical and power markets. "As Quest Integrity continues to grow, it is imperative that we meet our customers' needs and consistently deliver the exceptional results that the market has come to expect," said Jeff Ott, President of Quest Integrity Group. Quest Integrity Group has been awarded three major accreditations from international bodies. This reflects the hard work, knowledge and experience throughout the enterprise. The companies Quality Management and Environmental Systems are certified to ISO 9001:2008 and ISO 14001:2004. These systems provide the operational framework within Quest Integrity. In addition, the company holds an ATEX certification for InVistaTM, FTISTM, and HYDRATM advanced inspection technologies, which reflects the companies commitment to operational safety.

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About Quest Integrity Group

Quest Integrity Group is active in the development and delivery of asset integrity and reliability management services and solutions, which consist of technology-enabled, advanced inspection and engineering assessment services and products. The Enterprise is headquartered in Seattle, U.S.A.

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DENSO GmbH Germany wins IOCL tender for more than 2.4 million square meters of high quality pipeline coating

Application of DENSOLEN® AS39 P/ R20HT at IOCL in India.

IOCL - Indian Oil Corporation Ltd - India´s biggest pipeline operator and one of the leading oil companies worldwide is continuously rehabilitating parts of its more than 11.000km pipeline grid after 40 years of operation. The rehabilitation will be executed under operating conditions. For this, a 3-ply (inner wrap) and 2-ply (outer wrap) PE/ Butyl-Tape-System has been selected, due to its proven outstanding technical performance and the easy application. In the past DENSO Germany already delivered more than 2.6 million square meters of the DENSOLEN® AS39P/ R20HT-Tape System to IOCL for rehabilitation purposes. As in previous years, DENSO Germany has been recently awarded a new single order of IOCL for more than 2.4 million square meters (this equates to more than 335 football pitches!) of DENSOLEN® AS39P/R20HT to be delivered in 2014 and 2015 for about 320km of pipeline. OCL requests to protect its pipelines from corrosion for at least another 40 years to come. The technical committee of IOCL is convinced of the outstanding 3-ply/2-ply PE/Butyl-Tape-System technology. DENSOLEN®-Tapes and Tape-Systems are the only corrosion prevention system worldwide with a proven longtime experience of more than 40 years. The high performance tape system DENSOLEN® has successfully been used in numerous pipeline projects worldwide with more than 100 million square meters applied over the last 40 years.

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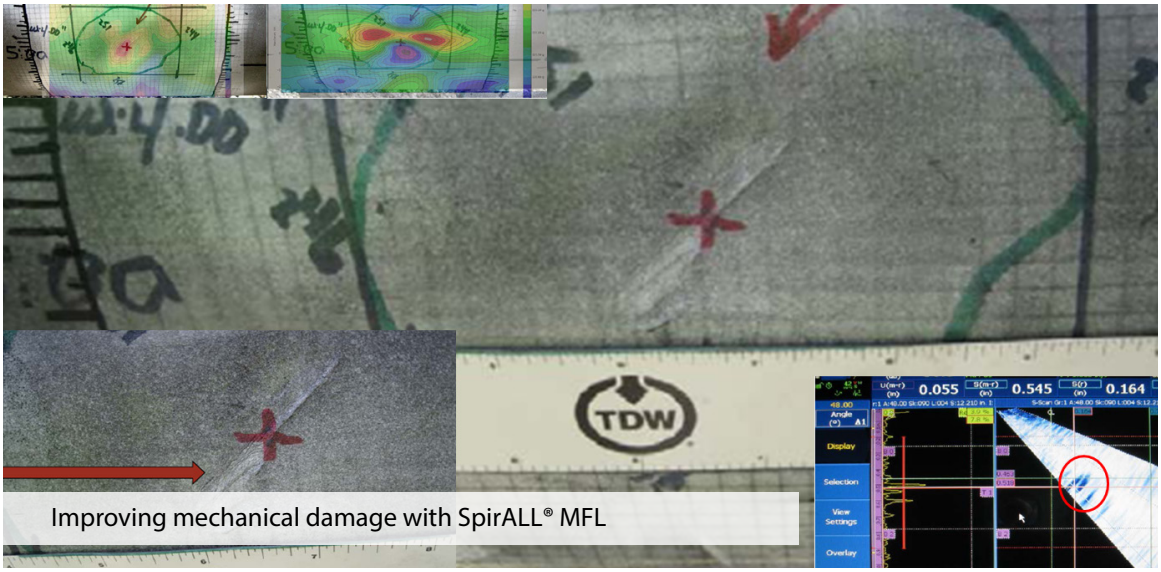
Improving mechanical damage prioritization via multiple datasets (MDS) with SpirALL® MFL

Categorizing severity of geometry defects, namely dents, has been generally classified in two categories; any dent with metal loss, and depths of a certain percentage, usually ≥2%. This prescriptive nature of such criteria does not account for other factors that may increase the severity of the condition. For example, is a dent that just happens to have coincidental metal loss more severe than a <1% dent that has re-rounded? Or, is a dent with coincidental metal loss really an immediate threat condition? Inspection technologies usually employed to find dents, and dents with metal loss, consist of deformation and high field axial Magnetic Flux Leakage (MFL). While these technologies are robust and have tremendous value for their intended purpose – bore assessment and detection of volumetric metal loss – they may not be the only technologies required to fully assess a pipeline for mechanical damage. By utilizing the multiple dataset (MDS) inspection platform – consisting of-deformation (DEF), high field axial MFL (MFL), low field axial MFL (LFM), SpirALL® MFL (SMFL) and XYZ Mapping – operators are presented with a more holistic view of their line integrity. Deformation is able to detect the slightest changes in bore. High field MFL is able to detect potential volumetric metal loss. Low field MFL is able to detect residual stresses from denting and permeability changes. And SpirALL® MFL provides detection of axially oriented metal loss and crack-like threats. All of this information feeds a mechanical damage prioritization process, developed by Battelle in the late 1900s and further enhanced by T.D. Williamson (TDW) – the developer of the MDS platform. The mechanical damage prioritization process allows inputs from each dataset, resulting in a severity ranking. For example, a <1% dent detected in DEF, whichhas re-rounded based on the LFM data, will place a higher priority than a plain ≥2% dent without re-rounding. Why? Rerounding changes the mechanical properties of the steel surrounding the dent, resulting in hardening, which could lead to cracking. Furthermore, SMFL will identify longitudinal gouging, undetected by MFL. Combine longitudinal gouging with a <1% dent, which has also rerounded, and cracking becomes a strong probability.

The figure is from a dent that calculated to 0.75% depth. The LFM data revealed re-rounding, which indicates residual stresses, and thus work-hardening, from the initial load causing the dent. MFL detects a portion of the metal loss, however, SMFL detects the full extent and orientation. The indications from each dataset, when correlated from the same inspection, combine to create a high priority mechanical damage location. Field results found this dent to have a depth of 0.95%, and Phased Array UT found associated cracking. A potential leak or rupture was avoided.



Improving mechanical damage with SpirALL® MFL

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ptc

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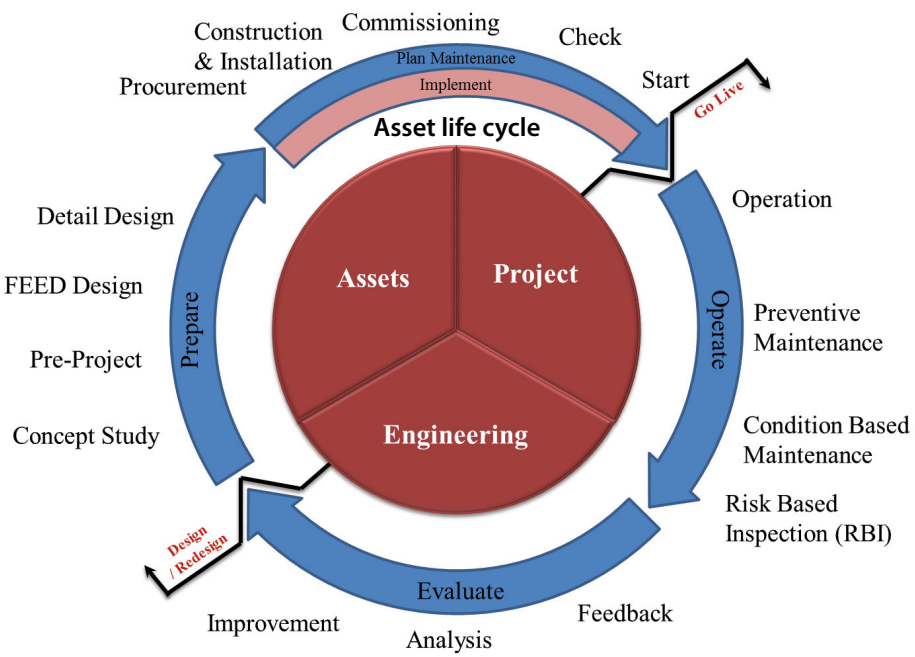
Euro Institute for Information and Technology Transfer in Environmental Protection

Confirming assets quality & reliability through proper implementation of Asset Management standard ISO 55001:2014

Today's industry and economy are driving the need for smarter Asset Management with increased expectations from companies, regulators and shareholders at a time when Assets are becoming much more inter-connected, instrumented, and intelligent. The benefits of improved Asset Management, with a consciously integrated focus on the whole life cycle value realization, are strongly proven in many industries and environments. Assets, and value realized from them, are the basis for any organization delivering what it aims to do. Whether the Assets are physical, financial, human or 'intangible', it is good Asset Management that maximizes value for money and satisfaction of Stakeholders' expectations. Asset Management is a systematic and coordinated activity and practice through which an Organization optimally and sustainably manages its Assets and Asset systems, their associated performance, risks, and expenditures over their life cycles for the purposes of achieving its organizational strategic plan, or, more simply, the optimum way of managing Assets to achieve a desired and sustainable outcome. Asset Management begins at the early stage of the Asset life cycle and provides assurance and control that the extended life assets, consistently engineered and constructed in accordance with approved specifications, operated within will defined design operating envelope, maintained and assessed at fixed intervals as per specific codes and standards to pro-actively resolving risk before it becomes a problem.

ISO 55000 is the first worldwide attempt to capture the generically applicable 'must do' items for the Asset Management that provides significant opportunities to refine Asset owner and service provider relationships, governance and regulatory frameworks and insurance, customer relations and other stakeholder confidence.

The integration of all aspects of the Asset life cycle from the first recognition of a need to design, acquisition, construction, commissioning, utilization or operation, maintenance, renewal, modification and/or ultimate disposal. ISO 55000 standard is based on the concept of the PDCA cycle (Plan-Do-Check-Act), meaning that measurable continual improvement is an integral part of the approach. The elements are defined such that they correlate with the requirements of other commonly employed international organizational frameworks including ISO 14000 (environmental), OHSAS 18000 (health and Safety), and ISO 9000 (quality management). Embracing the ISO 55000 standard demonstrates a high level of professionalism in whole life cycle management of the Assets and supports Asset intensive businesses and will provide the required level of Asset Management sustainability to the Facility Management. Independent certification or verification provides business, customer and other stakeholders with a clear indicator of their performance against Asset Management and wider business objectives.



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Turkish Kayserigaz applies Vortex Tubes on natural gas regulating metering stations to reduce energy cost

Kayserigaz, a natural gas distribution company in Turkey, has obtained a great experience by installing Vortex Tubes on Regulating Metering Stations (RMS-A) to save energy.

The Vortex Tube

The Vortex Tube (VT) is a device with no moving parts where the inlet gas flow introduced through the tangential orifice undergoes pressure reduction and following energy division in the highly rotated flow (vortex phenomenon). The vortex cold and vortex hot flows exit the VT separately forming the VT cold and hot outlets. Prior to exiting the VT, the hot flow is directed to warm up the unit's inlet orifice (self–heating provision) thus preventing freeze up in non-preheated depressurizing flow. Intensity of the vortex energy division depends on the ratio of the VT inlet and outlet pressures and is not affected by the gas flow rate through the unit.

When gas reaches its dew point the most vulnerable part for freezing off is small openings like pilots. Pilot gas heaters are installed to protect the pilot of the regulator from freezing.

Features of Vortex tubes:

- Vortex tubes are maintenance free once installed
- They do not consume any gas
- No moving part, no chance of overheating
- Easy to install or retrofit in new or existing facilities

Kayserigaz applied vortex tube to RMS-A in 2013 first to heat the pilots of regulators. By this innovation heating gas consumption has been reduced to zero. The gas in the pipe line is used to run the vortex tube which is heated to 40-45 °C and feed to pipeline. By vortex application Kayserigaz saved about $105.000 in one year.

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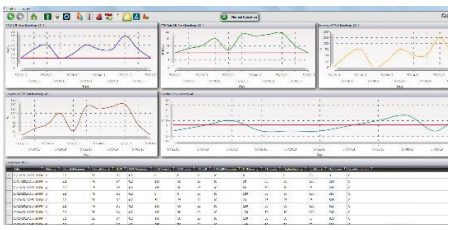
Vortex Tube applied to RMS-A in 2013


Before

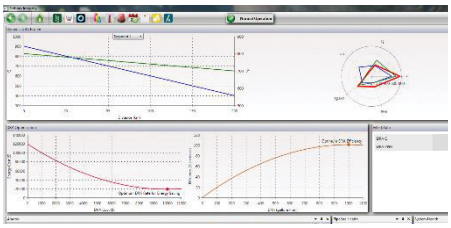

After

Work in process: Are oil companies extracting the full potential of their investments in data infrastructure?

In the past, data availability and reliability characterized the main challenges to understanding and improving operations in the oil & gas industry. Today, data flows in by the millisecond, however - most of the engineering practices remain the same. Outdated, unsynchronized excel sheets, time consuming manual calculations and or manual data entry into engineering software platforms plague the industry. At most, companies may have a engineering software solution integrated to the enterprise data historian to gather historical data, but what about the cross-practice correlation? In production optimization, historical well data correlated with current production information, offset well data and geophysical information together would provide an engineer with a strong foundation to establish and engineering assessment, make recommendations and optimize production. However, the geophysical information is in a department, current production information with another, historical production information with yet another department and this is not considering drilling and geophysical information. The first step to maximizing ROI in data infrastructure is through integration. Engineers can perform wonders when they aren't spending their time collecting data, but rather manipulating it. The Subject Matter Expert Modules (SME Modules) by Fathom Solutions allow engineers to peek into the future of their operations and solve critical failures before they occur. All SME Modules operate on a single robust platform, which provides a data collection, reconciliation and processing layer that allows the different SME Modules to operate with precision and accuracy with extremely rapid processing & response time. The SME Module platform provides data integra-



CrudeSpec_Screen



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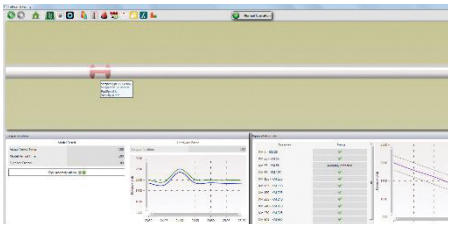

ScraperTracking_Screen

tion through API interfaces developed to access data from 3rd party applications. The modules offer real-time & historical trending, automatically generated reports, set point, compound and algorithmic alarming as well as the previously mentioned data collection and integration from 3rd party applications and databases. In addition to the basic features the SME Modules provide automated engineering workflows, a knowledge management and retention system, root cause analysis, seamless integration to 3rd party applications and KPI reporting for management overview. The Fathom Integrity SME module offers a deeper understanding into pipeline operations. Integrity – an integrated pipeline integrity management system - provides a single user interface that integrates ALL the operations and management systems, data sources, equipment, and engineering solutions in a pipeline's operational environment to provide a true integrated management system. Building on integration, Fathom Integrity advanced applications consume, process and enginer to enable pro-active asset management, increased efficiency, optimization and automated engineering solutions. Advanced applications, typically developed specifically for each-client, provide a solution to on-going operational and engineering problems our clients face. Existing applications include: Corrosion management & forecasting, DRA management & optimization, scraper management as well as valve actuation & flow assurance.

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15 years experience with fibre optical pipeline leakage detection

Geso GmbH Jena specialises in the field of fibre optical temperature measurements and successfully uses this technique to detect leakages along pipelines. Experience has shown that each pipeline system and the transported medium bring their own special requirements to the design and installation of fibre optical leakage detection systems. In the operational state of a pipeline a steady temperature field develops in the vicinity of the pipeline. In case of a leakage at the leakage location a temperature anomaly occurs. This temperature anomaly can stem from different physical reasons:

• Accruement of decompression coldness (Joule-Thomson-Effect) at the point of emission of the medium (for example: at high pressure gas pipelines),

• Accruement of evaporation coldness at the point of emission of the medium (for example: at pipelines for liquefied gas)

• A difference between the temperature of the medium that leaks from the pipeline and the surrounding temperature of the pipeline environment (for example: at oil and product pipelines, district heating and steam transport lines).

The distributed fibre optical temperature measurement principal provides a technique which enables the monitoring of the temperature field even at later not longer accessible locations over long periods and with a high spatial resolution (0,5 – 2 m depending on the sensor/pipeline length and the technical requirements). The advantage of this measuring method is that optical fibre, based on its specific character, is the sensor itself which allows a space-resolved temperature measure ment over its whole length (several km).

Preferred pipeline types for the method:

- High-pressure-gas pipelines
- Liquefied gas pipelines
- Brine pipelines
- Chemical product (for example: Phenol) pipelines
- Crude-oil pipelines
- Fat-oil pipelines
- Wet-oil pipelines
- Pipelines with a temperature difference between the transported medium and the pipeline vicinity of in minimum 3 - 5 K

Further application areas regarding pipelines are strain and settlement measurements. The fibre optical technique enables monitoring of settlements and strains over a 20km stretch.

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Northrop Grumam LITEF introduces its high performance inertial sensors on the Pipeline Technology Conference 2014

With its customized inertial solutions Northrop Grumman LITEF now provides the reliability and quality of products designed for aviation and military applications to the industrial market. This cutting edge technology is successfully introduced into industrial products for pipeline inspection systems, condition monitoring systems, photogrammetry units and measurement while drilling applications. During PTC 2014 in Berlin Northrop Grumman LITEF will present its inertial sensors on booth no 31.

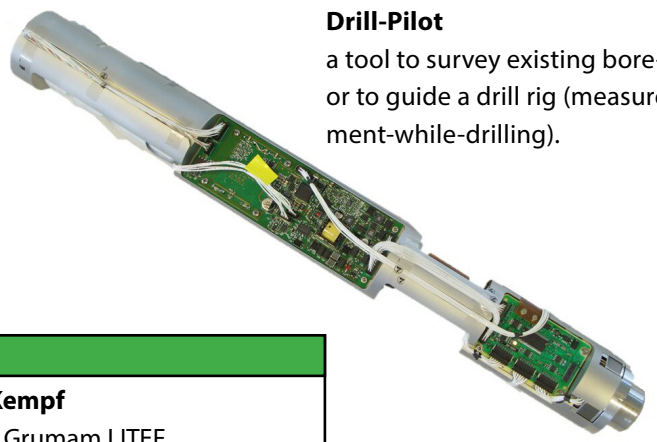
About NG LITEF

Northrop Grumman LITEF is since 50 years a supplier of inertial sensors, 6 axes inertial measurement units, attitude and heading systems and navigation systems. Core competences are sensors based on the latest fiber optic technology and on high performance MEMS-systems. The sensor technology ranges from classic mechanical gyros and accelerometers to fiber optic gyros to micro-mechanical gyros and accelerometers. All key components such as integrated optic assemblies, micro-mechanical sensors, ASICs and software are developed and produced in Freiburg Germany. Typical applications are platform stabilizations, reference units for mobile platforms as well as commercial and military systems. All Northrop Grumman LITEF systems are qualified, in serial production for worldwide customers and due to their German origin not controlled by US ITAR regulations.

Highlights are:

LCI-100
a navigation-grade 6-axes inertial measurement unit based on the latest fiber-optic technology. This product is suited for inertial measurement tasks in PIGGs or other pipeline inspection tools.

LCI-100N
a highly reliable and robust northfinding system. It can be easily integrated into systems requiring a fast and accurate heading information.



Drill-Pilot
a tool to survey existing bore-holes or to guide a drill rig (measurement-while-drilling).

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NDT
GLOBAL

Sustainable trenchless rehabilitation of supply pipelines applying static pipe bursting or close-fit lining

Björn Freimuth, Tracto-Technik GmbH & Co. KG, Germany

Leaking oil, gas or water pressure pipelines force utility companies to decide whether to repair, renovate or replace the defective pipes. The main decisive factors are the degree and type of damage, the sustainability of the method and the resulting rehabilitation cost. Modern trenchless pipeline rehabilitation techniques minimize traffic disruption, noise emission loads, dust and surface disruption, danger of damages to existing pipes and cables, intervention in ground water and soil, storage and transportation of the excavated soil. The choice of techniques ranges from punctual repair over partial renovation to complete renewal of the defective pipeline.

1. The Static Pipe Bursting method for pipe replacement

Static pipe bursting with GRUNDOBURST is an approved method for trenchless pipe replacement. The old pipe (from ND 50 on) is destroyed underground and the new pipe, often of larger diameter, is pulled in simultaneously. Defective gas and water pipes (pressure pipes) as well as sewage pipes having major damages, e.g. breakage, incrustation, root infestation, misalignment, split sockets, tears, leakages, mechanical wear and tear, can be replaced. New pipes from the coil or short pipes of almost any material (plastic or metal) up to ND 1000 can be installed. Daily capacities of 150 – 300 m are possible. Applying the static pipe bursting method overcomes the necessity to patch repair or renovate the old pipe and a new pipeline with a service life of the up to 100 years in is installed perfect static conditions.

Another major advantage when replacing supply pipes using static pipe bursting is that the method allows for increasing the pipe's cross section the new pipe, i.e. the capacity of the mins, as the following practical applications exemplarily show.

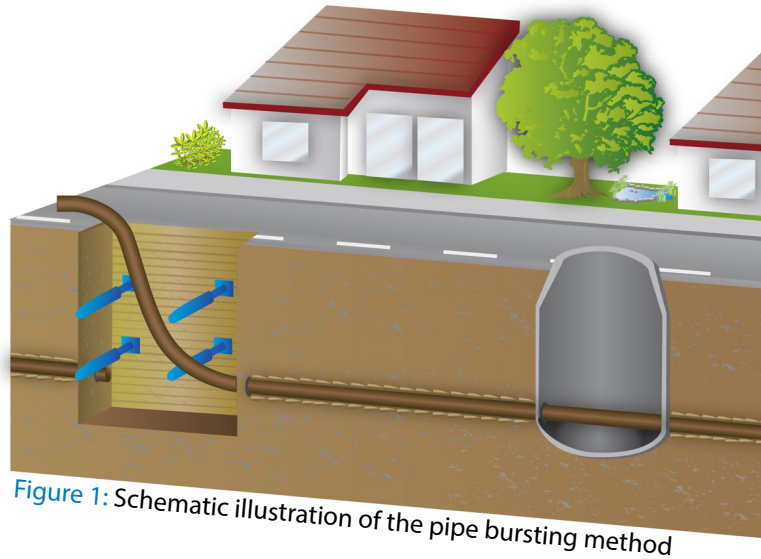

Figure 1: Schematic illustration of the pipe bursting method

1.1 A major pipe bursting task in Geneva

Technique:	Static pipe bursting
Old pipe:	Drinking water mains, Grey cast iron ND 500 (20")
New pipe:	Concrete with steel core OD 730 (29") wall thickness 52.2 mm
Pipe bursting length:	450 m
Client:	Geneva Public Utility Company (SIG)
Pipe bursting contractor:	PIASIO Geneva (COLAS), Switzerland
Remarks	The old pipeline running beneath a petrol station had slight bends.

The pipe bursting jobsite location in Geneva Meyrin

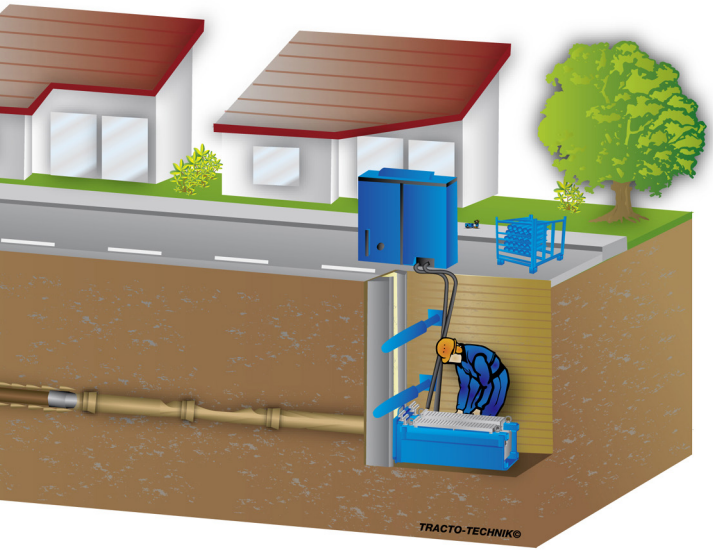


Figure 2: The new concrete pipe to be installed

It was a mammoth task the PIASIO company, a subsidiary of COLAS SWITZERLAND, had ahead of them in Geneva Meyrin. Using a GRUNDOBURST type 2500 G (250 t pulling force), an over-aged and under-dimensioned 500 mm drinking water transport pipe made of grey cast iron had to be replaced by a 730 mm concrete pipe with a steel core, manufactured by BONNA. In Geneva, when extending public traffic routes, in this case for the highways network, it is the normal procedure to check all underground supply networks and, if necessary, renew or repair them. Generally, up to 5 years after completion of work on public roads the authorities are not allowed to excavate any subsequent excavations. The aim is to prevent any danger areas, ugly road patchwork and constant repair procedures, which could cause further accidents on the extended highways network. This project was to cause as little disruption as possible to the adjoining property owners and traffic flow. This was also one of the reasons for the use of the pipe bursting replacement method, whereby the old pipe is broken and the new pipe, which is often of an increased diameter, is directly pulled into the existing pipeline bore path. This replacement method is suitable for most pipe materials with the main advantage being the trenchless installation of a new pipe with a relevant, extended service life. In this case the renewal of the pipe stretched over several sections with a total length of 450 m.

Figure 3: The GRUNDOBURST2500G with 2500 kN (250 t) pulling force inside the construction pit

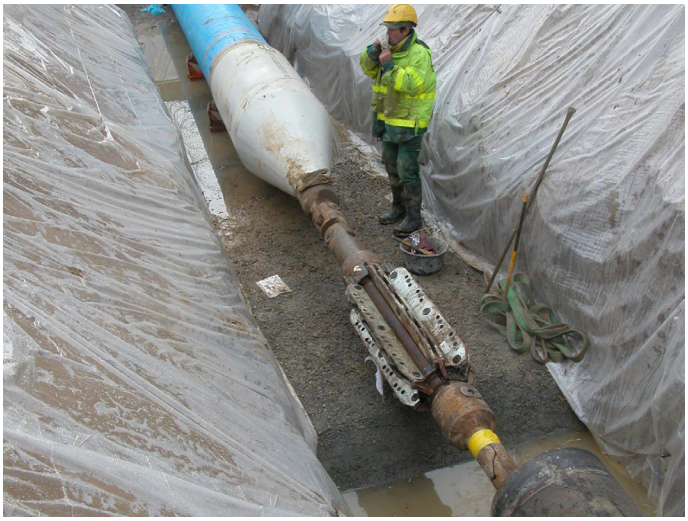

Figure 4: The pipe string with the 810 mm expander and the 600 mm cutting blades

Figure 5: The expander with the new pipe string attached is pulled in, the old concrete pipe is destroyed simultaneously

Jean-Michel BALMAT, responsible for "No-Dig" at COLAS SWITZERLAND commented: **"This was an extreme advantage, especially for a task of this magnitude, which was also a first for us. The challenge was in the difficult replacement section of 125 m in length, which had slight bends laid at a depth between 1,70 m and 3 m further complicated because the pipeline ran beneath a petrol station."**

The adjoining property owners each received brochures in advance, giving them information and explanations regarding the Grundoburst pipe bursting method and the separate working steps. Numbered signposts were set up on the footpath to indicate the progress of working steps. This exemplary measure was highly acclaimed by the affected adjoining property owners and was much appreciated by them.

For the GRUNDOBURST 2500G a pit was excavated with a length of 10 m. With its enormous pulling force of 250 t old pipes from ND 300 to ≤ ND 1000mm can be renewed. The GRUNDOBURST rig, even with the highest pulling force demands, has to be stabilised securely inside the machine pit. A stabiliser made of steel reinforced concrete fitted to the front of the rig was specially produced to ensure its stability. Lowering and retrieving the special ladder-shaped Quick-Lock bursting rods, which a simply linked in place, was easily accomplished using a special fast attachment lifting device. Without taking into account all the preparatory and auxiliary work the actual bursting and pipe replacement process took just 3 days.

2. Replacement of a cast iron gas main with new PE pipes in Germany

Technique:	Static pipe bursting
Host Pipe:	Gas main, Cast iron ND 200 (8")
New pipe material:	PE with protection coating ND 225 (9")
Pipe bursting length:	200 m (657 ft)
Client:	Dortmunder Energie- und Wasserversorgung GmbH
Contractor:	PAUL SPEECK GmbH, Germany
Location of job site:	City of Dortmund, district Nette, Germany
Duration:	1 day

The project was carried out in the sidewalk area of the Mengeder Street in Nette, a district of Dortmund, where 200 m (657 ft) of cast iron pipe ND 200 (8") were to be replaced by a PE pipe ND 225 (9") by means of trenchless installation. The crew of the local pipe bursting contractor, the comapny Paul Speeck GmbH, took the challenge to renew the complete service line in one single operation. The 12 m (39 ft) long PE pipes were laid out and welded together. Due to the confined space, the new pipe string had to be divided into three sections, forcing the crew to interrupt bursting twice for welding. The working pits for 6 house connections, the starting pit (6.00 x 1.00 m (19.5 x 3 ft) with 3.00 m (9 ft) insertion slots) and the exit pit (3.00 x 1.00 m (9 x 3 ft)) were excavated. After disconnecting the house service pipe and setting up the bursting rig Grundoburst 400G, pushing in the Quick-Lock rods could commence. By clicking the rods together without having to screw them together, the rod insertion phase was completed in only 75 minutes. The roller blade cutters, expander and new pipe were connected to the rods immediately thererafter. Bursting and pulling in was started.

Figure 6: The long pipe was lifted into the starting pit and connected there. The insertion slots in the background.

Figure 7: The rig's telescopic frame is extended in order to recover the roller blade and the expander

The power and telecom cables lying directly above the new pipe forced the crew to position the roller blade cutters in front of the expander at 90°. During the pulling-in process, the cast iron pipe fragments collected in the intermediate pits were removed to prevent them from getting jammed when continuing the pulling operation. Thus work was halted intermittendtly to enable risk-free removal of the shards from the pits. In spite of this interruption and the necessary pauses for welding, the complete pipe string was already pulled in the early afternoon. After 75 minutes, the expander with the new pipe string was pulled into the exit pit. In order to allow recovery of the bursting tools, the telescopic frame of the bursting rig was extended upon arrival of the bursting tools. Only after this, the roller blade cutter was pulled into the pit and removed. In the following, the operation was repeated with the expander and the new pipe.

Roughly 20 minutes after completing the bursting operation, the exit pit was completely cleared and the preparatory measures for the pressure test and the reconnection of the pipe were started. Pipe pulling was performed without negative effects on the water line in the vicinity. With the expander OD 280 mm (11") for the PE pipe ND 225 (9"), displacement of the soil and the host pipe could be maintained to a minor scale. A further remarkable fact: the depth of cover was only between 0.90 m (2.9 ft) and 1.10 m (3.6 ft). After a successful pressure test, all house connections were reconnected to the gas main on the following day.

2. The pipe reduction method for close-fit lining

Due to its high pulling force being optimally transferred, the GRUNDOBURST system can also be used for the renewal of pipes applying close-fit lining techniques such as the pipe reduction method. The reduction method is a relining technique with the new pipe (liner) being of slightly larger diameter than the host pipe in which it is pulled leaving no annular space so that grouting is not necessary. The outer diameter of the PE new pipe (liner) is temporarily reduced using a mechanical device named reduction dye. After the PE liner has been pulled completely into the host pipe, the pulling force is removed and the PE pipe returns to its original diameter until it presses 'close-fit' against the inside wall of the host pipe. This process is called "memory effect".

Up to now hydraulic cable winches with up to 400 kN pulling force have been used to pull in the new pipe. Meanwhile the GRUNDOBURST system is also being used for the reduction method as pulling force and pulling speed are adjustable and the patended QuickLock bursting rods guarantee constant and even force transmission. Depending on the GRUNDOBURST model pulling forces up to 2500 kN can be applied. The reduction method is applicable where static pipe bursting is not possible for whatever reason and suitable for the repair of circular cross sections of corroded, torn or leaking gas, water and sewage pipes from ND 75 up to approx. ND 1200 (3" to 48").

2.1 Fast pipe renovation utilising the pipe pipe reduction method in Adelaide

Technique:	Reduction method
Old pipe:	Water main, Concrete lined steel ND 600 (24")
New pipe:	PE ND 560 (22")
Pipe bursting length:	250 m
Client:	SA Water, City of Adelaide,
Pipe bursting contractor:	Interflow PTY Ltd, Adelaide

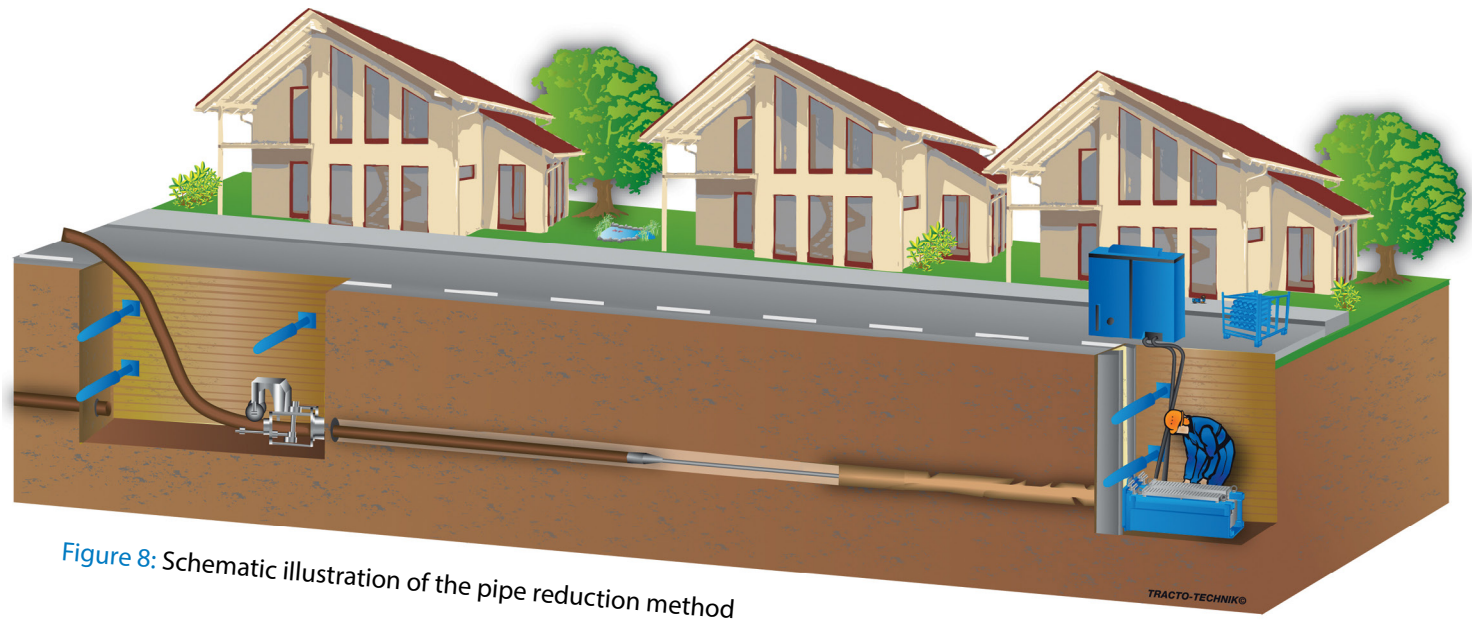

Figure 8: Schematic illustration of the pipe reduction method

TT's Australian sister company TT Asia Pacific was contacted by leading pipe renewal specialist, Interflow, to discuss the benefits of its GRUNDOBURST pipe rehabilitation systems for an exciting project the company was commissioned to undertake on behalf of SA Water in the city of Adelaide, Australia.

The scope of renovation works was extensive at over 6 km, consisting of numerous pulls of varying lengths. The existing locking bar, 600 mm mild steel, concrete lined trunk water main was installed in 1898 and is the oldest locking bar steel pipe in South Australia. Due to the critical nature and age of the main SA Water had decided to renew the asset using a specialist close-fit lining method known as pipe reduction.

The Marion/Holbrook Road projects in Adelaide were to be undertaken in challenging urban areas with high traffic volumes which meant a compact, versatile system was required to reduce space on site and ensure that heavily trafficked arterial roads into the city could be kept flowing with ease. Hence open trenching was virtually excluded and trenchless renovation using the GRUNDOBURST provided the optimum solution.

Figure 9: The pilot head prior to insertion into the 600 mm mild steel main.

Moreover the GRUNDOBURST 1250G enables contractors to reduce costs due to fast set up times and quick installation speeds. All these advantages convinced the contractor and Interflow purchased the GRUNDOBURST 1250G system from TT Asia Pacific's head office in Brisbane. The new product pipe chosen was to be an HDPE, ND 560, PE 100 pipe which was to be pulled through a reducing dye and the existing main under constant tension using the GRUNDOBURST until it reached the retrieval pit. Inside the old pipe the new pipe to returns naturally towards its original diameter until it presses closely against the inner wall of the existing main.

Figure 10: The new HDPE pipe ND 560, PE 100 entering the reducing dye prior to insertion.

Initial above ground trials were undertaken by TT Asia Pacific and Interflow personnel to simulate the pipe behaviour prior to work commencing on the initial 250 m length of the pipeline being renovated. Once complete, the GRUNDOBURST 1250 G was set behind extension frames in the 'start pit' and the complete string of QuickLock rods were inserted into the host pipe with ease and at an impressive speed. During this time the reduction dye was set up and installed at the 'retrieval pit' and upon arrival of the pilot push head, a quick connection was made to the GRUNDOLOG tensile load measuring device and then to the pulling head was connected to the product pipe. The GRUNDOLOG system enables the contractor to measure and record the pull data and tensile loads exerted onto the product pipe which could then in turn be downloaded and stored for future records if required.

The pull-in process with the GRUNDOBURST went very smoothly with the pulling forces encountered all being within the capabilities of the system/pulling rig and the pipe specifications. The complete string of PE product pipe was installed quickly and efficiently to the delight of all present on site.

TT Asia Pacific personnel, along with a product specialist from TT's head office in Germany, were present during the initial installation process to assist with the technical transfer and were pleased to work alongside the experienced and professional crews at Interflow.

2.2 Close-fit lining of a gas mains using the reduction method in the UK

Technique:	Reduction method
Old pipe:	Gas main, Cast iron ND 458 (18")
New pipe:	PE 80 SDR21, ND 469 (18.5")
Pipe bursting length:	60 m
Client:	National Grid / PMC, UK
Pipe bursting contractor:	Morrison Utility Services, UK
Remarks:	Installation speed of 180 meters in 1h 35 min

National Grid is one of the world's largest utilitiy companies and the biggest gas and power supplier in the UK. TT-UK working together with the National Grid Gas specialist pipe repair division, PMC, and their contractor Morrison Utilities, has successfully been using the reduction method to refurbish large diameter medium pressure gas mains. The existing 458 mm (18") diameter cast iron main has been relined with a 469 mm SDR21 - PE80 pipe. The usual cumbersome 40 tons capacity hydraulic capstan winch was replaced with a specially adapted GRUNDOBURST 800G pipe replacement rig, fitted with the unique QuickLock ladder type rods for fast, reliable and safe handling. Due to some of the offset bends of the existing main, the QuickLock rod's flexible joints easily overcame the associated pushing and pulling side load forces. Up to now hydraulic cable winches with up to 400 kN pulling force have been used to pull in the new pipe. Meanwhile the GRUNDOBURST system is also being used for the reduction method as pulling force and pulling speed are adjustable and the patended QuickLock bursting rods guarantee constant and even force transmission. Depending on the GRUNDOBURST model pulling forces up to 2500 kN can be applied. The reduction method is applicable where static pipe bursting is not possible for whatever reason and suitable for the repair of circular cross sections of corroded, torn or leaking gas, water and sewage pipes from ND 75 up to approx. ND 1200 (3" to 48").

2.1 Fast pipe renovation utilising the pipe pipe reduction method in Adelaide

Installation speeds were as high as 180 metres in just 1 hour 35 minutes, but what was equally impressive was the ease of docking the new pipe in the specially constructed reduction dye which together with the GRUNDOBURST's push pull brake and fingers, ensured minimum pipe contraction both during the installation and reversion process. PMC have been delighted with the improved performance and productivity using this innovative lining method and intend to use this technique in the future.

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Using the Linear Risk Integral (LRI) approach in pipeline QRA for a better application of risk mitigation measures

Urban Neunert, ILF Consulting Engineers, Germany

Abstract

Minimizing the risks resulting from hazardous scenarios during the design of a given system is of superior importance in order to ensure a safe operation and to demonstrate and satisfy regulatory requirements. A common approach in the process industry for this purpose is to use Quantitative Risk Assessment (QRA) as a decision-making tool to effectively apply risk mitigation measures. The results of a QRA allow quantifying individual and societal risks and assessing them against risk criteria. While individual risk is usually presented in risk contours showing the acceptable and tolerable risk limits, societal risk is often shown in an FN-curve which presents the cumulative frequency F of all system-related hazardous events that result in N or more fatalities.

Regarding cross-country pipelines, societal risk and hence the FN-curve results are related to the pipe length. However, the likelihood and the consequences of hazardous events and subsequently the risk vary along the alignment of a pipeline due to e.g. different environmental, geological and operational conditions, different pipe geometries and population densities. Therefore, using an overall FN-curve approach for a cross-country pipeline has a major shortcoming: A precise detection of the pipe sections which are mainly contributing to the risk is not possible, which makes an effective application of risk mitigation measures difficult.

This can be overcome by presenting the societal risk using the Linear Risk Integral (LRI) approach which addresses the societal risk along the length of the pipe route. The LRI can be interpreted as the cumulative risk for the society, i.e. sum of individual risks caused by the pipeline at the related location. The LRI approach allows comparing different pipeline systems and routes, providing an integrated overview of the pipe related risks and applying risk mitigation measures in a highly efficient manner.

1. Introduction

Cross-country pipelines are the safest and most economic way for transmission of hazardous substances. Nevertheless, reducing the environmental and societal impact of accidental pipeline incidents is getting more and more important in order to improve both overall safety and public acceptance of cross-country pipelines. Although the CONCAWE Report 2011 and the EGIG Report 2011 show that the number of accidental incidents at oil and gas pipelines is decreasing consistently over the last decades which bears witness to the industry's improved control of pipeline integrity, **incidents like the Manitoba gas pipeline explosion in 2014 (Young 2014) indicate that understanding, managing and reducing risks shall be still of superior importance during the design, construction, commissioning and operational stages of a pipeline system, in order to ensure a safe operation.**

Process safety's guiding principle "Keep it in the Pipes" reflects its main goal, i.e. to avoid loss of containment leading to a release of hazardous material. A loss of containment occurring at a pipeline transporting hazardous substances may lead to several risk scenarios affecting population and the environment. Depending on the material properties, explosions, fireballs, jet fires, pool fires or toxic contamination may occur. In order to prevent such incidents to happen, their risks have to be investigated, assessed and properly managed.

For the investigation and assessment of risks in process industry, several techniques like a Risk Based Inspection (RBI) or traditional risk analysis and risk assessments exist (API 2000). They can be performed according to a qualitative, quantitative or semi-quantitative approach. Their results are often used to apply risk mitigation measures during early design stages.

Pipeline laying, Procejt: West Austria Gas Pipeline System

Regarding quantitative approaches, a QRA is able to deliver results with a high level of detail and accuracy. QRA has been used since the late 1960s and has grown from a coarse tool to a precise tool demonstrating cost effective risk acceptability and risk minimization (Nalpanis 2011). Several guidelines (e.g. de Haag 2005, RIVM 2009) and commercial software exist for the general performance of a QRA for process facilities. However, carrying out a QRA for cross-country pipeline systems requires special considerations during all study stages. In BSI 2009 a guide to the application of pipeline risk assessment is given. Recently, Spoelstra 2011 presented a method for the QRA of underground pipelines transporting hazardous substances. Further, Spoelstra 2013 describes the risk methodology for transmission pipelines transporting chemicals with which the consequences for land-use planning can be calculated. Neunert 2011 recommends special considerations related to the QRA of gas transmission pipelines

Assessing the risks related to individuals and the society of a given system, the individual and the societal risk have to be quantified. For both, risk criteria exist depending on governmental or company-related regulations showing the acceptability and tolerability limits. The results regarding individual risk are usually mapped in risk contours around the investigated facility or presented in form of a risk transect. Their probability values show the chance of fatality of one individual staying 24 h/day outdoor without protecting clothes at a certain location on-site or adjacent to the establishment. However, since hazards associated with pipelines tend to be high consequence low frequency events, it is more appropriate to use societal risk in order to assess the acceptability of pipeline risk. The societal risk results are usually shown in an FN-curve which shows the cumulative frequency F of all system-related hazardous events that result in N or more fatalities.

Using the FN-curve approach for a cross-country pipeline provides valuable information on the overall societal risk. However, this method has also the major shortcoming that it cannot reflect the variations of the societal risk along the pipe length. These variations are due to location related parameters such as failure frequency, severity of consequences and density/distance of population. Therefore, following only the results shown in the FN-curve would make it difficult to identify the locations with the highest contribution to the overall risk and to apply selected measures to reduce the risk to as low as reasonably practicable (ALARP).

The present paper presents an alternative approach for the presentation of the societal risk and compares it with the conventional FN-curve method. It is shown that the novel approach based on calculating the Linear Risk Integral (LRI) as a function of pipeline length allows overcoming the shortcomings of an FN-curve.

2. QRA Approach

One general goal of a QRA is to quantify the risks to population related to a given facility - i.e. the individual and societal risk - and assess them against risk criteria in order to satisfy regulatory requirements. In order to ensure that the overall risk is acceptable or tolerable, risk reducing measures are applied by following the ALARP principle (as low as reasonably practicable). Since risk is the product of likelihood and consequences of an undesirable event, it can be quantified by knowing the outcome of the event (number of fatalities) and its frequency of occurrence. Summing up the risk numbers of all hazardous events leads to the overall individual and societal risk values.

A typical QRA is comprised of five steps:

a. System definition
b. Hazard identification
c. Consequence analysis
d. Frequency analysis
e. Risk assessment

In the following the QRA steps are explained roughly focusing on special considerations for their application on cross-country pipelines transporting hazardous materials.

2.1 System definition

In the system definition phase, the goals and objectives are clarified and the boundaries of the investigated system are defined based on the physical and operating limits. Regarding a pipeline, the physical system is usually a pipe section or a complete pipeline system. Additionally, site specific data is collected during the system definition phase including information on weather, material properties, population density, operating conditions, potential ignition sources and on existing risk reducing measures. Since all this data may vary along a given pipe alignment, the data collection for conducting a QRA can be very time consuming. Further, information about soil cover depth, soil quality, coating conditions and laying procedures has to be included for buried pipelines.

For long cross-country pipelines it is therefore recommended to perform a coarse screening of the pipeline and select dedicated 'worst case' pipe sections which will be investigated in the risk assessment. Since population density is the major parameter influencing the risk, pipe sections adjacent to high populated areas are considered to have the highest risk contribution. However, during screening of the pipeline route, critical sections have to be additionally identified and included in the investigations; e.g. road crossings, river crossings, seismic areas, etc.

2.2 Hazard identification

Several techniques exist for the identification of hazardous scenarios, i.e. a Hazard and Operability Study (HAZOP), a Failure Mode and Effects Analysis (FMEA), checklist approaches or a Fault-Tree Analysis (FTA). Regarding cross-country pipelines, the hazardous events are scenarios leading to a release of hazardous material followed by potential fire, explosion or contamination events. As proposed in BSI 2009 and Spoelstra 2011, a QRA for transmission pipelines should cover a full bore rupture and typical leak scenarios depending on the incident causes and the pipe diameter. A hazardous scenario occurring at a pipeline may occur due to different causes. However, depending on the amount and type of release (continuous, instantaneous) and the material properties, different hazardous events may occur. Since a loss of containment may appear at any position along the pipe alignment, the calculation of the events is related to discrete locations. Proper discretization plays an important role, as it affects calculation effort and accuracy. According to Jo 2005, the discrete pipe sections should be short enough so that the calculated results are not influenced. A value of 10 m applied for the discretization length is proposed in the regulatory standards for performing risk analysis of transmission gas pipelines in Switzerland (Swissgas 2010).

2.3 Consequence analysis

A given hazardous scenario is followed by a chain of consequences which is modelled starting from the release of hazardous material and ending up in the determination of quantified values describing the hazardous effects on the population. Performing an event-tree analysis allows to visualize and investigate the pathway from the point of release to the possible end events. Commercial software provides calculation results of the discharge and dispersion behaviour of the released material, which depends on the amount and physical properties of the material, on its toxicity and flammability, on leak size and release conditions as well as on weather data. The release from pressurized below ground pipelines is usually accompanied by a crater formation yielding the discharged material towards vertical direction. The hazardous effects of toxic or contaminating and persistent materials can be directly quantified from dispersion calculations. Considering flammable materials, the effects of heat radiation or overpressures are determined by calculating the fire or explosion events, respectively. Therefore, the presence of oxygen (air) and ignition sources have to be known. Regarding cross-country pipelines aligned in rural areas, explosive events creating overpressures are hardly expected to occur, since an explosive pressure build up needs a flammable vapour cloud trapped in a confined environment. However, several events like the Ghislenghien gas explosion (ARIA 2009) showed that explosions scenarios have to be considered in a pipeline risk assessment. Possible heat radiation effects occur due to flash fires, fireballs, jet fires or pool fires.

BTC project: Pipeline construction in difficult terrain

2.4 Frequency analysis

The quantification of the individual and societal risks within a QRA requires a frequency and probability analysis. This includes the frequency of occurrence of all identified hazardous scenarios, the probabilities of different weather scenarios, the immediate and delayed ignition probabilities and the probability of presence of population located indoor and outdoor at the affected area. Empirical data is used to define the appropriate frequencies and probabilities. For cross-country oil and gas pipelines, appropriate values can be found in the CONCAWE Report 2011 and EGIG Report 2011, respectively.

2.5 Risk assessment

As mentioned above, risk is the product of likelihood and consequence. Thus, the risk results for all investigated hazardous scenarios of a given system can be quantified by combining the results of the consequence analysis with the frequency and probability data. Individual risk results (i.e. individual risk contours) are generated out of a risk summation approach by summing up the probabilities of fatality from all identified hazardous events to a location-specific probability of fatality. The societal risk results measure the risk to all people located in the effect zones of the incidents. It generally shows the frequency distribution of multiple fatality events. As mentioned above the societal risk is usually presented in forms of FN-curves showing the cumulative frequency F of all events leading to N or more fatalities.

The acceptability and tolerability of the individual and societal risk is defined by assessing the risk results against risk criteria. In case the results show unacceptable or intolerable risks, appropriate risk reducing measures have to be applied following the ALARP principle. For cross-country pipelines it is more effective to reduce the risks at special locations which mainly contribute to the overall risk. Regarding the individual risk, these locations can be easily identified by analyzing the individual risk contour plots. However, using FN-curves to identify the locations of the hazardous events with the highest contribution to the societal risk is often difficult. Therefore, it is recommended to use a linear approach for the presentation method of the societal risks related to pipelines.

3. Presenting and assessing societal risk

Performing quantitative approaches for identifying, assessing and managing risks related to population, results in individual and societal risk values. In order to reduce risks with appropriate measures it is required to present and understand the risks properly. The most common way of presenting societal risk is generating FN-curves. An FN-curve shows the cumulative frequency F of all events leading to N or more fatalities related to the investigated system. Figure 1 shows a typical FN-curve for a given establishment and the appropriate societal risk criteria in the UK and the Netherlands according to CCPS 2009.

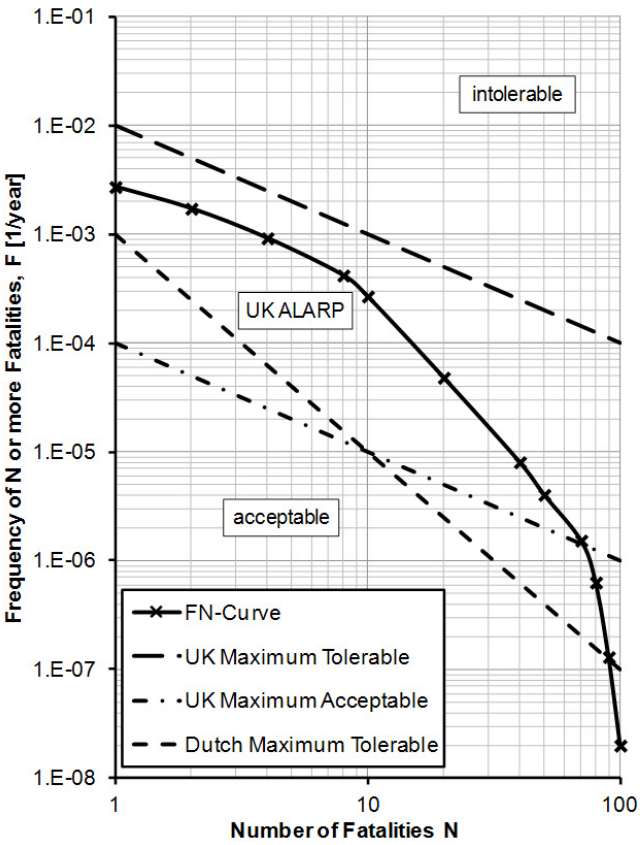

Figure 1: Typical FN-curve and UK/Dutch societal risk criteria for a process facility

As shown in Figure 1, by following the FN-curve approach the assessment of societal risk against given risk criteria can be easily performed. Depending on the risk limits the societal risk can be 'acceptable', 'intolerable' or 'tolerable but not acceptable'. In the latter case, risk reduction has to be performed according to the ALARP principle, i.e. the risk is only tolerable if risk reduction is impracticable or its costs are in disproportion to the gained improvement.

In order to enable a comparison between different facilities the societal risk can be reduced to a single number known as the Societal Risk Index (SRI) or Potential Loss of Life (PLL). According to API 2000, this index is generated by multiplying the frequencies of occurrence F with their corresponding numbers of fatalities N of each single event and summing up these numbers for all events related to the investigated facility. In order to assess societal risk the FN-curve is the most popular approach. However, regarding the presentation of the societal risk of cross-country pipelines it has a major shortcoming: A valid comparison between different pipelines or pipeline routes with different lengths is not feasible, since an overall FN-curve shows the cumulated frequencies of all events related to a facility. Therefore, several proposed methods exist in literature with appropriate length-related risk criteria. According to Spoelstra 2011, the societal risk of pipelines in the Netherlands is assessed per 1 km pipe length. The tolerability frequency limit F_{lim} of 1 km pipeline for the occurrence of an event resulting in N or more fatalities is given in Eq. (1).

$$F_{lim} = \frac{10^{-2}}{N^2} \quad (1)$$

A similar societal risk FN criterion exists in the UK. According to BSI 2009, the acceptability limit for the societal risk of any 1 km section of a pipeline route is defined by Eq. (2) separating the acceptable area from the ALARP area. The tolerability limit is defined as two magnitudes above the acceptability limit.

$$F_{lim} = \frac{10^{-4}}{N} \quad (2)$$

Figure 2 shows the resulting frequency limits of Eq. (1) and Eq. (2) in an FN-diagram, corresponding to the societal risk criteria of 1 km pipeline in the Netherlands and UK, respectively.

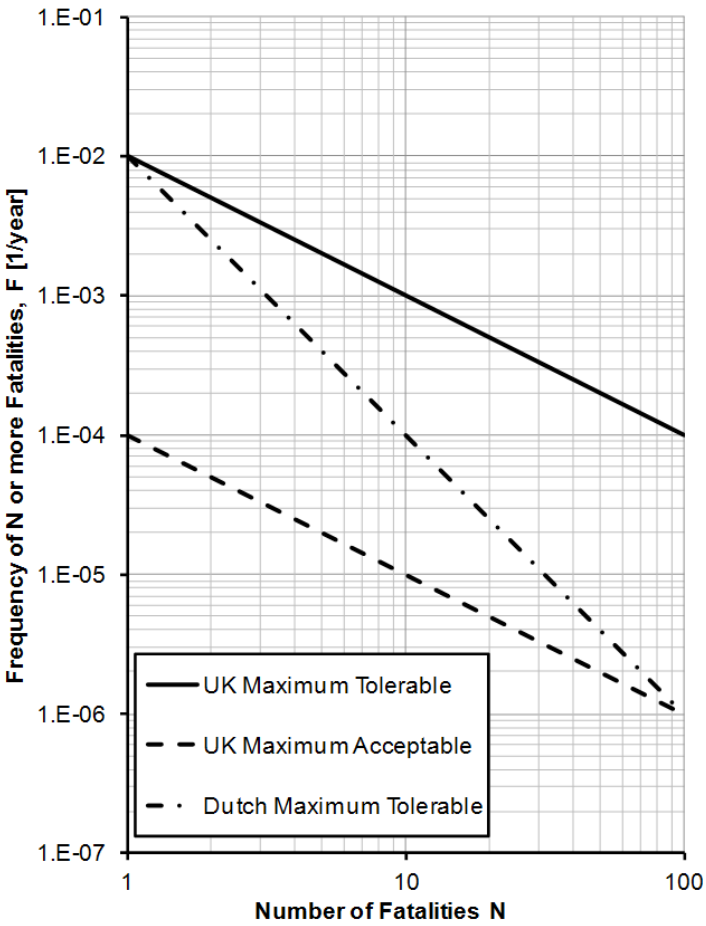

Figure 2: UK/Dutch societal risk criteria for 1 km of pipeline


BTC project: Ceyhan Terminal

In BSI 2009 it is proposed to generate a site-specific FN-curve by multiplying the frequency values F by a factor of 1 km divided by the total pipe length and to assess the resulting societal risk against the criteria shown in Figure 2.

In Swissgas 2010 a standardized approach is described to assess the societal risk of gas transmission pipelines in Switzerland. Following the Swiss methodology, the highest number of fatalities of the possible events occurring along the pipeline route is determined for each 10 m section of pipe. If events lead to consequences exceeding 10 fatalities at a given location, an FN-curve is generated for a pipeline segment of 100 m at this point. The FN-curve of each investigated 100 m pipe segment is assessed against risk criteria presented in Figure 3.

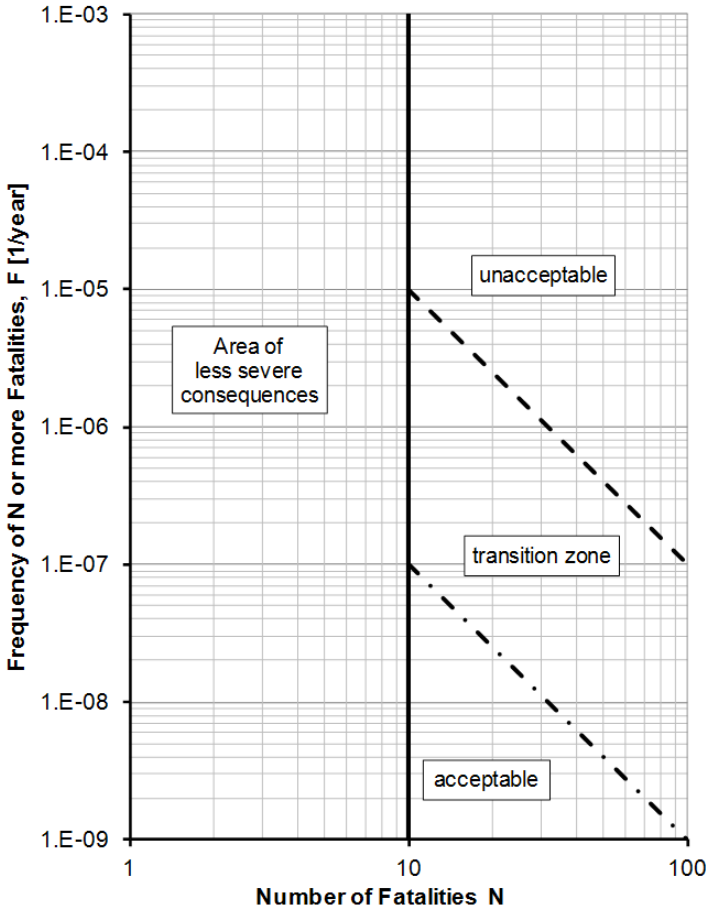

Figure 3: Societal risk criteria in Switzerland, Swissgas 2010

The above mentioned approaches indicate that for the successful assessment of pipeline risk, the FN-curve has to be related to a specific length allowing a comparison between different pipeline routes. However, they still have three major shortcomings which are described in the following:

a. Assessing societal risk is based on a section-wise determination of FN-curves and comparison against risk criteria. Besides the pipeline length, the segmentation and selection of the pipeline route sections is not defined in the regulatory regarding the exact position of the section's boundaries. It is obvious that this may have a significant impact on the societal risk results. To overcome this it is proposed in BSI 2009 to calculate a single site-specific FN-curve by multiplying the frequency values by a factor of 1 km divided by the total pipe length. However, using this method, peak areas prone to high risks can hardly be identified.

b. Consequences and failure frequencies of hazardous events usually vary along a given pipeline route. Therefore, significant differences of the societal risk over length exist. The efficient application of risk mitigation measures - e.g. re-routing, relocation of occupied zones, increased soil cover, increased pipe wall thickness, mechanical protection, visual signs (e.g. marker posts, warning tape), change in operational conditions, etc. - requires a precise detection of the pipe sections which are mainly contributing to the risks. Regarding long cross-country pipelines, the results and conclusions of a site-specific FN-curve are often insufficient for the application of adequate risk reduction measures. Further, for identifying the exact positions where to apply reduction measures, even sectional FN-curves related to 1 km or 100 m pipeline length are often not suitable.

c. For long cross-country pipelines, the presentation of the societal risk results requires the calculation and presentation of numerous FN-curves. This may often result in a documentation overload. Considering a pipeline system of 100 km length, the generation of 100 FN-curves is required in the Netherlands. In Switzerland a number of up to 1000 FN-curves may be required for the same pipeline

An alternative approach to present the risk of pipelines is addressing the societal risk results along its length, which is based on calculating the location-related Linear Risk Integral (LRI). The LRI can be interpreted as the Societal Risk Index (SRI or Potential Loss of Life, PLL) of a linear segment with a discrete length Δl. The LRI of a pipeline segment is calculated of the frequencies F and corresponding number of fatalities N of n contributing events related to the discrete segment length Δl. For a pipe segment located at a distance x the LRI can be determined with Eq. (3).

$$LRI(x) = \sum_{i}^{n} \frac{F_i(x) \cdot N_i(x)}{\Delta l} \quad (3)$$

The LRI is understood as the measure of societal risk per km and year and can be interpreted as the cumulative frequency of fatalities per year caused by 1 km of pipeline at the related location. An example is shown in Figure 4. Figure 4 presents the LRI curve over pipe distance of a given pipeline with a length of 18.5 km.

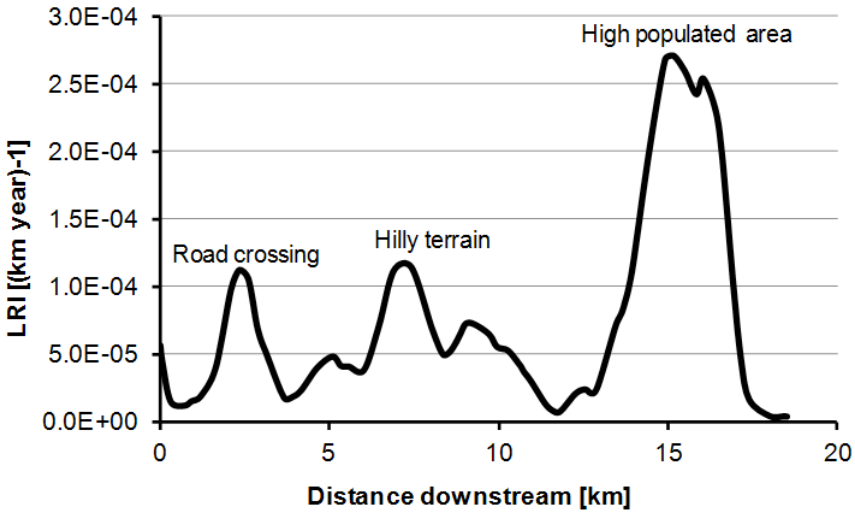

Figure 4: Societal risk of a pipeline: LRI curve over pipe distance

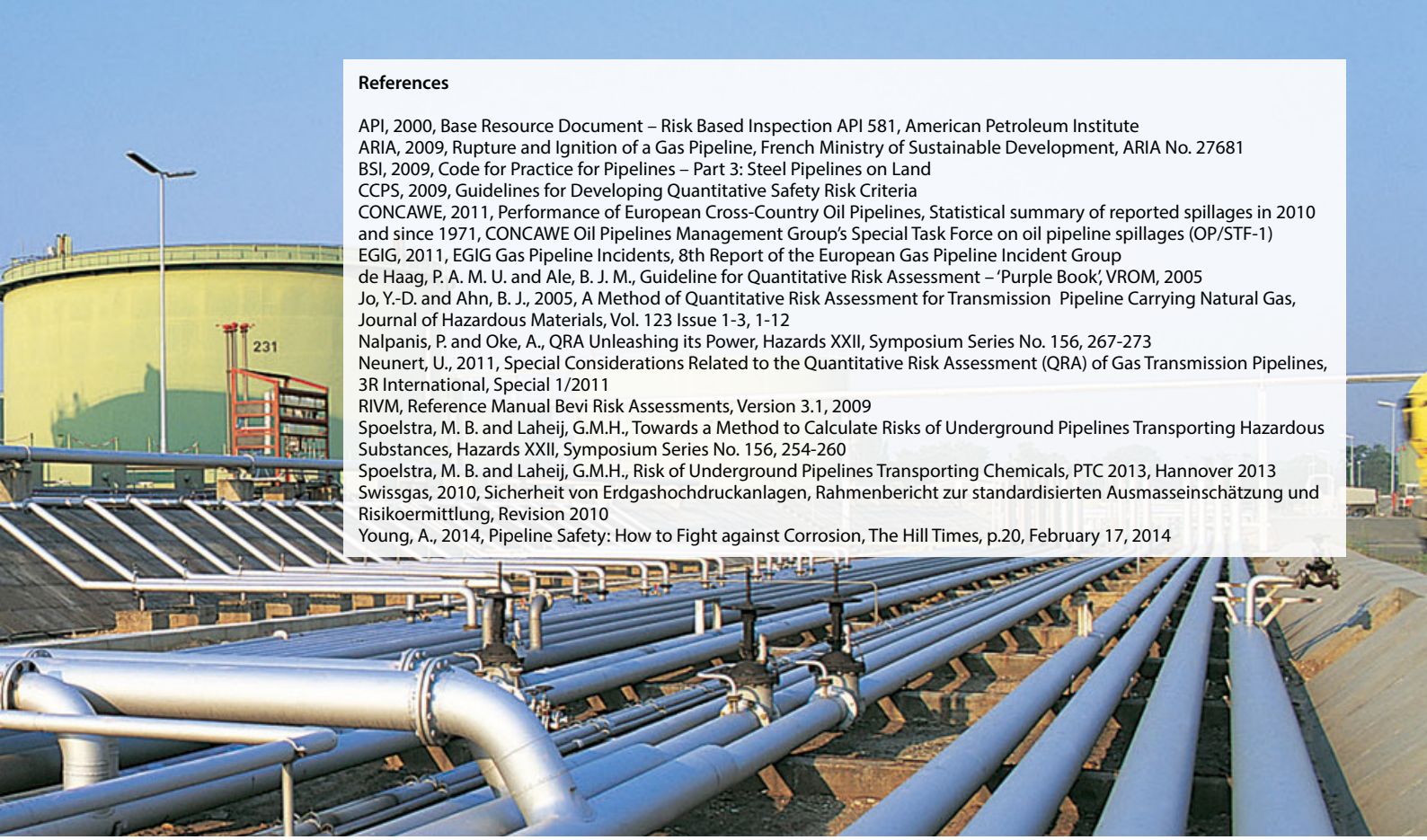

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Figure 4 indicates the location of pipe sections with a significant contribution to the societal risk. Near km 2.5 pipeline the frequency of incidents due to external impacts following vehicle accidents at a road crossing and subsequently the societal risk is increased. At km 7 the pipe is aligned through hilly terrain where a higher probability of land slides impacting the pipeline leads to a higher societal risk. For hazardous events occurring at the pipeline near km 15 an increased number of fatalities and therefore higher consequences are expected due to the vicinity of a high populated area. The results in Figure 4 clearly show where to implement measures in order to achieve the most effective risk reduction. As risk is composed of the frequency and consequences of several hazardous events which are based on several failure causes, a detailed investigation is required to select the best applicable risk reduction measures. Therefore, generating an LRI curve over pipe length is an advantageous method for comparing different pipeline systems and routes, to provide an overall view of the pipe related societal risk and to apply risk reduction measures efficiently. Due to the fact that regulatory risk criteria corresponding to the presented 'LRI over pipe distance'-curve in Figure 4 does not exist, the generation of section-wise FN-curves is additionally required to conduct a regulatory risk assessment.

4. Summary and conclusion

The present paper discusses different approaches for the presentation and assessment of societal risk results of cross-country pipelines generated with a Quantitative Risk Assessment (QRA). The different steps of a pipeline QRA are explained which lead to the quantified societal risk values which are usually presented in FN-curves. Based on the FN-curve approach the assessment of societal risk against risk criteria can be performed. Concerning the comparability of different pipeline systems and the application of risk reduction measures, it is shown that calculating and generating FN-curves is not sufficient. An alternative approach is presented based on a location specific determination of the societal risk along the pipe alignment by calculating the Linear Risk Integral (LRI). Presenting an LRI curve over pipe distance leads to a precise identification of the pipeline sections with the highest risk contribution. This allows a highly efficient implementation of potential risk reduction measures.

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PII Pipeline Solutions
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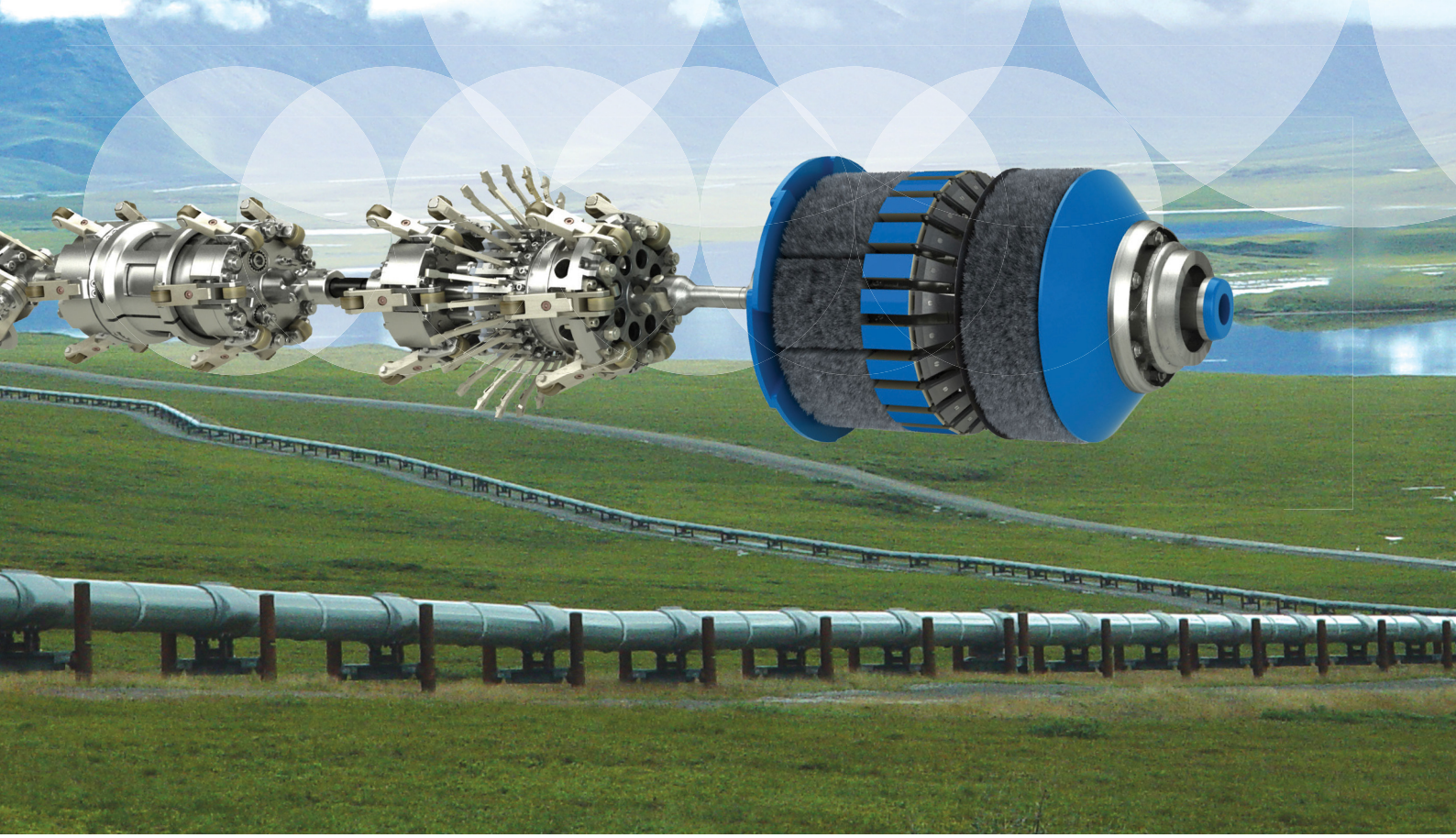
MagneScan capabilities keep expanding

The latest MagneScan™ in-line inspection tools continue to impress after more than four years in operation. This fourth generation MFL technology from PII is shorter, lighter and more flexible than ever before, and deliver a higher level of data quality. The size range is now extended up to 36 inches with enhanced variable gas bypass capability in the larger diameters to enable full inspection of high-speed gas pipelines with no loss of production.

MagneScan combines multiple inspections in a single run. The foundation MFL inspection is complemented by a fully integrated high-resolution caliper and a GIS mapping unit as a standard option for improved data alignment. The corrosion detection capability is 5% of wall thickness at 90% POD, while depth-sizing accuracy is ±10% at 90% certainty at tool speeds up to 5 m/s.

To complement the multi-mission hardware capability, PII has developed software for flexible processing, analysis and reporting. Analysts and pipeline operators can see all data sets aligned together in the latest version of the client viewing software. Similarly, the new single integrated report covers all data sets and can include integrity engineering recommendations if requested. The result is a fast reporting interval with a fully integrated inspection and integrity assessment to facilitate timely planning.



Al Shaheen

2014 report card

- Serving customers in: Australia, Austria, Belgium, Canada, China, Croatia, Czech Republic, Denmark, France, Germany, Holland, Indonesia, Ireland, Italy, Luxembourg, Mexico, New Zealand, Norway, Qatar, Saudi Arabia, South Africa, Spain, Switzerland, UK, USA
- Total inspections: 750+ inspections
- Pipeline diameters: 6, 8, 10, 12, 14, 16, 17, 18, 24, 30, 32, 34, 36
- Total distance inspected: 33,000+ km (20,500+ miles)
- Longest run: 385 km (240 miles)
- Pipe: onshore & offshore, seam welded, spiral welded, seamless
- Media: condensate, CO_2, crude oil, diesel, jet fuel, natural gas, naphtha, nitrogen, water
- First runs success: 95%
- Dig verification: 150+ digs, 1,000+ features, 90%+ in tolerance

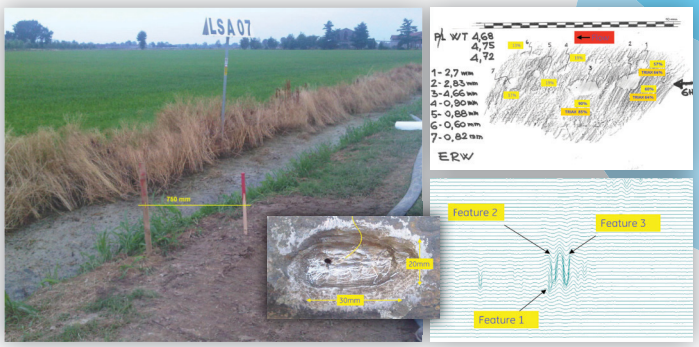
Performance
confirmed around the world

The full MagneScan system (hardware, software and analysis) continues to exceed pipeline operators' expectations around the world – with performance covering categories of features that are typically not visible to traditional MFL systems. MagneScan's ability to detect and size pinholes and axial slots, and previously undetectable weld defects was confirmed in dig verification data from the earliest inspections:

- At the end of 2011, a 2 mm deep, 5 mm diameter pinhole was reported and verified in a 14" 139 km pipeline in Australia.
- PII partnered with a Canadian gas operator to further investigate identification of axial slots. In a blind test, the system repeatedly detected axial slots less than 1 mm wide and even detected features as narrow as 0.4 mm.
- A Chinese operator used MagneScan to study spiral weld anomalies in late 2011, and a US operator used the system to assess girth weld defects in a large diameter gas pipeline in early 2012. Again, MagneScan demonstrated its outstanding capability to detect, discriminate and size features within the weld area – including circumferential crack openings of only 0.25 mm.

The combination of dig verification data and blind-test results completed in partnership with operators worldwide has conclusively demonstrated the system's capabilities regarding previously sub-specification features (i.e. pinholes, axial and circumferential slots). PII is therefore publishing an improved specification covering these additional feature classes recognized by both API & POF.

As the system's proven capabilities continue to expand, further specification and reporting enhancements are anticipated in the near future.



MagneScan brings together critical aspects of metal loss inspection and analysis – including highly accurate detection and sizing, precise data alignment, GPS location and feature prioritization for verification and planning.

Doability of Trans-Caspian pipeline and deliverability of turkmen gas to Turkey & EU

Oğuzhan Akyener, TPAO, Turkey

Abstract

Due to increasing demand, gas supply is one of the most strategic energy security issues for huge importers. By taking this into consideration, Caspian region - where important gas supply potentials exist - is directly related with the huge importers' energy security issues, mainly which are EU, China, India and Turkey. As an important gas supplier country locating in Caspian Region, Turkmenistan and her future gas supplies are becoming more important for the importers mentioned above. As a result, each importer is preparing long term plans and developing new projects to import the gas resources from Turkmenistan.

One of the most popular projects -related with Turkmen gas resources- is Trans Caspian gas pipeline, which is planned to transport Turkmen gas through Caspian Sea to Azerbaijan and then with other available pipelines to Turkey and Europe. Naturally, this pipeline is an important energy security issue for Turkey-Azerbaijan and EU. However, there are important political, technical and economic challenges to overcome. In this study, after a short outlook into the gas politics in the Caspian Region -mainly Turkmenistan related issues-; importance of Trans Caspian gas pipeline project will be described. Then, doability of this popular project will be evaluated from the technical-political and economic perspectives. Additionally, Iran's claim to transport Turkmen gas through Iran to Turkey instead of Trans Caspian project will economically be compared.

Caspian is the most important region according to her proved gas reserves potential in the world (%46,7 of world share)

Caspian Region Gas Politics & Importance of Turkmenistan

After oil and coal, natural gas is the most important energy resource in the world. Moreover, since being clean & easy to use and shale gas effect on prices, natural gas is expected to be the second world's leading consumed fuel in the future. Caspian, involving Russia-Turkmenistan-Kazakhstan-Uzbekistan-Azerbaijan-Iran, is the most important region according to her proved gas reserves potential in the world (%46,7 of world share). Moreover, due to the geographical properties (locating in the middle of the important consumers; China-India-EU & Turkey), importance of Caspian region for world gas politics is increasing. Table 1 on the right gives numerical information about the reserves-production & consumption values of Caspian and Caspian gas demanding countries. From table 1, it is observed that there is an important volume of gas supply potential (such as 250 bcma) in Caspian region and an important demand volume (such as 400 bcma) in nearby areas.Due to difficulties faced during transportation, storage and marketing procedures of natural gas, long term plans and forecasts are much more important than any other energy resource. That's why, for coherent gas politics, long term estimations are very important. Forecasts for the 2035 supply and demand potentials of these countries are given in table 2. In this scenario to focus on Turkmenistan; she has the 3rd important gas reserves and 2nd (except Iran-no logical estimations due to sanctions) supply potential for the demand markets. Besides, India-China-Turkey and EU are the possible future buyers.

		Azerbaijan	**Turkmenistan**	Uzbekistan	Kazakhstan	Iran	Russia	**India**	**China**	**EU**	**TR**
Proved Gas Reserves	tcm	0,9	**17,5**	1,1	1,3	33,6	32.9	**1,3**	**3,1**	**1,9**	**0,006**
Gas Production	bcma	15,6	**64,4**	56,9	19,7	160,5	592.3	**40,2**	**107,2**	**153**	**0,6**
Gas Consumption	bcma	8,5	**23,3**	47,9	9,5	156,1	416.2	**54,6**	**146,6**	**456**	**39**
Demand Volume	bcma	-7,1	**-41,1**	0,9	-10,2	-4,4	-176,1	**14,4**	**39,4**	**303**	**38,4**
1 year Prod / Reserves		0,017	**0,004**	0,052	0,015	0,005	0,018	**0,031**	**0,035**	**0,081**	**0,100**
Result		SUPPLY	**SUPPLY**	SUPPLY	SUPPLY	SUPPLY	SUPPLY	**DEMAND**	**DEMAND**	**DEMAND**	**DEMAND**

Table 1: Energy Statistics of the Main Energy Players in Caspian Region

		Azerbaijan	**Turkmenistan**	Uzbekistan	Kazakhstan	Iran	Russia	**India**	**China**	**EU**	**TR**
Gas Supply	bcma	40	**140**	80	60	No Est.	350				
Gas Demand	bcma							**250**	**650**	**640**	**85**

Table 2: Gas Supply-Demand Potentials of Main Energy Players in Caspian Region

A brief insight into the Turkmenistan energy market

- An important gas exporter in the region (2nd)
- today has an oil exporting capacity more than 100 000 bbld.
- Today has a gas exporting capacity more than 40 bcma.
- Lacks of sufficient foreign investment
- Locating too far from the important markets (China-India-EU-TR)
- Lacks of sufficient oil export pipeline infrastructure
- Majority of gas is exported to Russia and some portion of gas is exported to China and Iran
- Important portion of gas reservoirs are high pressure and temperature reservoirs and have high percentages of H2S and CO2; means not easy to develop due to economical & technical aspects
- Due to important gas reserves attract all other players in the region
- Some energy security targets are:

1. To access Pakistan, India and European gas markets via planned pipelines
2. To complete the construction of these relevant pipelines (TAPI & Trans Caspian)
3. To complete East-West pipeline inside Turkmenistan and have the ability to transport South East resources to the Caspian Sea markets (Then from Trans Caspian to EU)
4. To solve conflicting claims over the maritime and seabed boundaries of Caspian Sea with Iran & Azerbaijan

Gas Export Infrastructure of Turkmenistan

Table below summarizes existing and planned gas export infrastructure of Turkmenistan. As in the table highlighted, Trans-Caspian gas pipeline project is the planned infrastructure to transport Turkmen gas to TR and EU.

		Gas Export Pipelines				
		Name of Pipeline	From (Supply Country)	Through (Countries)	To (Markets)	Capacity (bcma)
Turkmenistan	Existing	CAC	Turmkenistan	Turk-Uzb-Kaz	Russia	100
		Korpezhe KK	Turmkenistan	Turk	Iran	13
		Dauletabat-Kangiran	Turmkenistan	Turk	Iran	6
		Central Asia-China	Turmkenistan	Turk-Uzb-Kaz	China	40
		Bukhara-Urals	Turmkenistan	Turk-Uzb-Kaz	Russia	20
	Future	East-West	Turmkenistan	Turk	Caspian	30
		Tapi	Turmkenistan	Turk-Afg-Pak	India	34
		▶ Transcaspian	Turmkenistan	Az	Turkey-EU	30
		Central Asia-China X	Uzbekistan	Uzb	China	18

Table 3: Gas Export Pipelines of Turkmenistan

Introduction of the Trans-Caspian Gas Pipeline Project

The idea to transport Turkmen gas to Europe continues to be popular since the independence days of Turkmenistan. This idea has developed as the Trans-Caspian gas pipeline project. Many changes in the structure and strategies of this pipeline occurred. For instance, the plan used to include NABUCCO and SCPX pipeline however political and commercial decision makers have changed the roots and projects. With the last updates, Trans-Caspian gas pipeline is planned to run under the Caspian Sea from Türkmenbaşy to the Sangachal Terminal, then to connect to EU and Turkey via SCPFX and TANAPX and will carry 30 bcma gas annually.

Map 1: Proposed Trans-Caspian Pipeline

1. Milestones of the Project

Before the investment decision of Trans-Caspian pipeline project, there are important milestones and risks to be considered. If these milestones cannot be overcomed then this project will not be realized.

1.1 Political

The sea border conflict between Caspian countries negatively affects the investment possibilities in the region. As seen from the map below Turkmenistan has disagreements with both Azerbaijan and Iran. But Trans-Caspian pipeline project is directly affected by the conflicts between Azerbaijan and Turkmenistan. This is the first issue that has to be overcomed. This issue is also related with the sharing of some important oil and gas fields around the borders such as ACG & Kepez, therefore the solution will not be easy (also EU&US supports to have a solution).

1.2 Commercial

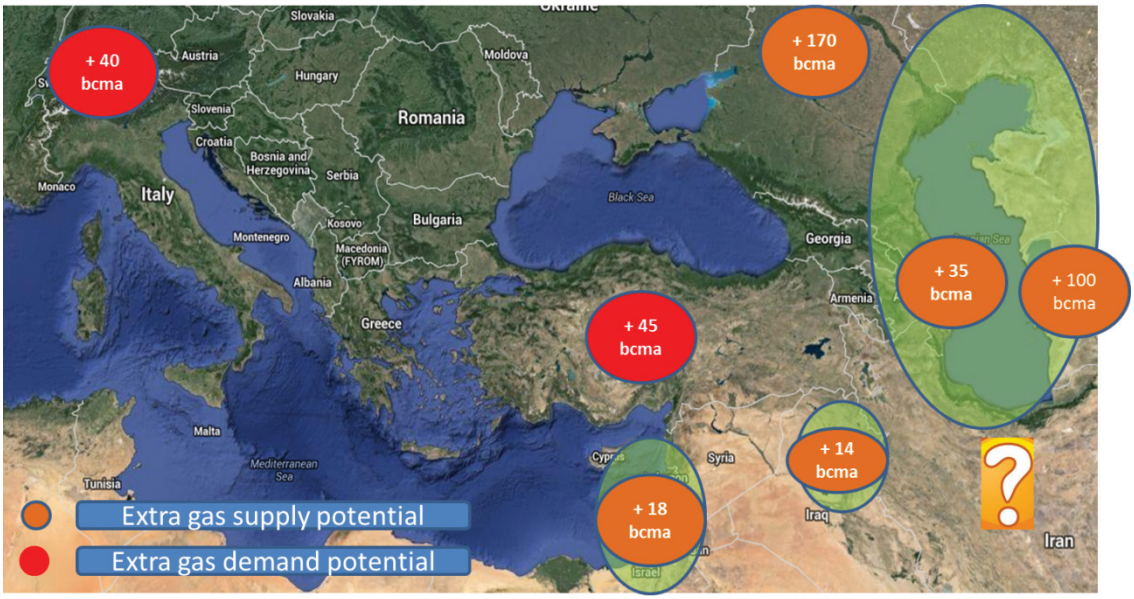
Commercial milestones may be the most difficult steps to overcome. Hence, the commerciality of a pipeline is directly related with the commerciality of gas production projects. Not increasing or decreasing gas prices (due to the changes in agreement types); huge tariffs are the main elements for gas development projects to be commercial.

Trans Caspian gas pipeline is planning to transport Turkmen gas to EU & TR markets. For this pipeline to be reasonable, production costs of the fields, tariffs of the related pipelines, EU & TR gas market prices are important. If a more economical way is found for transportation of Turkmen gas then there will be no way for Trans-Caspian pipeline project.

1.3 Market Related

Hence gas and pipeline projects needs long term plans and projections before development investment decision, for evaluation of Trans-Caspian pipeline's referred markets (TR & EU) earliest 2035 projections have to be studied. Map3 shows extra gas supply & demand potentials of the related countries in 2035. According to these estimations there seems enough market potential in EU & TR for 30 bcma (max. capacity of Trans-Caspian) gas of Turkmenistan. However, market potential can change due to other supply possibilities such as Russia – Iran – Iraq and Western Mediterranean. The most deterministic factor in the market share will be the gas prices. Naturally, Azeri gas is one step forward than the Turkmen gas in the struggle due to less tariff costs. Moreover, if the political situations and sanctions in Iran changes, then due to average gas production unit costs and gas quality parameters; Iran and Iraq will be one step forward than the Turkmen gas in TR & EU markets. As a result, market is another risky milestone for the doability of Trans Caspian pipeline project.

Map 2: Caspian Sea Border Problems



Map 3: EU-TR-Caspian-Middle East 2035 Gas Supply & Demand Potentials

1.4 Financial

The owner of the project will probably be Turkmenistan and the project is supported by EU-US. This shows that both Turkmenistan can finance such an investment with her own resources or easily find credit from western funds. As a result, financial milestones do not contain risk for the project.

Note: Azerbaijan may possibly be a partner of this project but this is a weak probability due to SOCAR's investment projections around the region.

1.5 Technical

Technical milestones are not too crucial to overcome. Caspian Sea and the planned Trans-Caspian pipeline root's water depth is not so much (i.e. maximum 300 meter in the deepest point). Also the geographical structures and climate effects are not so difficult to overcome. As a result, there are no important technical and technological milestones to overcome. After the Azerbaijan/Shangachal Terminal point, the transportation of Turkmenistan gas will be another question and will technically and commercially be evaluated again. Hence, SCPX, which is going to transport SD2 gas to TR, and TANAP (through Turkey to EU) capacities and extension possibilities have to be technically and commercially studied.

2. Evaluation of these Milestones

As described in the previous chapter, financial and technical milestones of the project are not obstacles for the doability of Trans Caspian gas pipeline project. To evaluate the political, commercial and market issues, initially some technical aspects of the pipeline and the other possible roots those will be used to reach TR & EU markets have to be studied.

Technical Properties of Trans-Caspian (Estimation):

- Start Point: Turkmenbasy / Turkmenistan
- End Point: Shangachal Terminal / Baku / Azerbaijan
- Total Length: 338 km
- Max. Water Depth: 300 m
- Operating Capacity: 30 bcma
- Inlet Pressure: 10 bar
- Outlet Pressure: 90 bar
- Pipe Diameter: 60"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 7 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 75 USD/1000 m3

2.1 Possible Roots for Turkmen Gas after Shangchal Terminal

2.1.1 From AZ to TR

Hence Azerbaijan is not a market for Turkmen gas and all gas will have to be transported to TR and then some portion to EU, 30 bcma gas will directly be transported to Turkish border. The only gas transportation facility from Azerbaijan to Turkey is SCP and new extended looped version SCPX pipeline. Total capacity of SCP & SCPX is around 26 bcma and with some extension works capacity can be increased. However, for 30 bcma gas transportation, a new standalone pipeline will be a better solution. Moreover, Azerbaijan estimated to have extra gas supply potential for SCPX after 2025. So, for any SCPFX option, Azerbaijan is going to use that capacity.
From Shangachal Terminal to Turkish border a new standalone gas pipeline is planned to be constructed. With technical properties:

- Start Point: Shangachal Terminal
- End Point: Turkish Border
- Total Length: 690 km
- Operating Capacity: 30 bcma
- Inlet Pressure: 90 bar
- Outlet Pressure: 10 bar
- Pipe Diameter: 58"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 8 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 85 USD/1000 m3

2.1.2 From TR to EU

In the Turkish border there are 2 options:

first: due to commercial and political issues %40 of 30 bcma gas is sold in Turkey and %60 is transported to EU.
Second: all gas sold in TR market or transported and sold in EU market.

TR to EU Option1:
12 bcma is transported & distributed inside TR market via BOTAŞ's own facilities and other 18 bcma is transported to EU via looped TANAPFX. (However, today BOTAŞ do not have enough capacity to accept 12 bcma gas in the eastern border of Turkey, so BOTAŞ also has to make an investment for such an option.

Moreover, TANAP is going to be constructed with an operating capacity of 23 bcma. Then in 2026 this capacity is planned to be extended (TANAPX) up to 31 bcma. And this extra volume will be devoted for extra Azerbaijan gas supply potential. So, this option will not be the most probable choice).

- Start Point: Western Turkish Border
- End Point: Eastern Turkish Border
- Total Length: 1000 km
- Operating Capacity: 18 bcma
- Inlet Pressure: 90 bar
- Outlet Pressure: 10 bar
- Loop Pipe Diameter: 54"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 10 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 110 USD/1000 m3

TR to EU Option2: Similar to TANAP a new 30 bcma capacity standalone gas pipeline is constructed and TR's portion is transported to the western Turkey and EU's portion is transported to western Turkish border. This seems the most probable scenario.

- Start Point: Western Turkish Border
- End Point: Eastern Turkish Border
- Total Length: 2000 km
- Operating Capacity: 30 bcma
- Inlet Pressure: 90 bar
- Outlet Pressure: 10 bar
- Pipe Diameter: 48"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 12 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 130 USD/1000 m3

TR to EU Option3: All gas is sold to Turkey. For this option all gas is planned to be sold to BOTAS in the Turkish border and all inside Turkey transportation investments will belong to Turkey. However, situation of Turkish market, demand potential and BOTAŞ's infrastructure are other unknowns those make this choice non-probable.

TR to EU Option4: All gas is sold to EU. Similar to TANAP a new 30 bcma capacity standalone gas pipeline will be constructed all gas is transported to EU. Technically this option is similar with the second option, only the average tariff is estimated as 5 USD less (due to transportation all volume up to the western point of Turkey).

- Start Point: Western Turkish Border
- End Point: Eastern Turkish Border
- Total Length: 2000 km
- Operating Capacity: 30 bcma
- Inlet Pressure: 90 bar
- Outlet Pressure: 10 bar
- Pipe Diameter: 48"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 12 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 125 USD/1000 m3

3. Evaluation

3.1 Political Evaluation

While transportation of Turkmen gas to EU contains market and commercial risks and this volume of gas is not a vital issue for EU energy security strategies, political border conflict between Azerbaijan and Turkmenistan cannot be solved only for Trans-Caspian pipeline project. Azerbaijan's aim to be a gas transit country is understandable. However, hence the solution of the border conflict affects the share of the offshore oil & gas fields such as ACG and Kepez, this aim (being a gas transit country) will not be so much exciting for Azerbaijan. Moreover, Turkmenistan may have other more commercial options to sell her own gas (as India & China) Russia - Iran's effect for the solution of this border problem in the Caspian Sea is also important. They may not let such a solution which will be in favor of EU.

3.2 Market Evaluation

Due to higher estimated tariff and unit production costs, Turkmen gas cannot compete with other gas suppliers in Turkish and EU gas markets. All Azeri – Russia – Iraq – Iran gas supplies will be cheaper for those markets. And the supply potentials of these countries are estimated to meet the demand in these markets.

3.3 Commercial Evaluation

To start the commercial evaluation, an average gas production cost for western Turkmenistan region has to be estimated. Hence important portion of gas reservoirs are in western Turkmenistan are high pressure and temperature reservoirs and have high percentages of H2S and CO2; the unit costs to develop and produce the fields will be high. That's why an average of 150 USD / 1000 m3 will be taken as the unit cost. Condensate & gas ratios and condensate sales will not be included into the estimations. Hence usually in condensate rich gas reservoirs, condensate sales are more profitable then gas and sometimes it may be better to inject gas to produce more condensate, so this issue is not included into the scenarios. For average commercial evaluations, all values are MOD. For average market prices; for EU: 400 USD /1000 m3 and for TR 450 USD / 1000 m3 is estimated. The calculated netback prices for only gas sales are given in table 4.

	Transcaspian	AZ-TR Pipeline	Options			
			Option 1	Option 2	Option 3	Option 4
	75	85	110	130	0	125
Revenue			420	420	450	400
Netback			0	-55	60	-5
All values are USD/1000 m^3 MOD prices						

Table 4: Evaluation of Commerciality - Netback Prices of the Scenarios

As seen from table 5 the only commercial option is option3 which will not be possible due to Turkish market demand profiles. The most probable scenario's, which is option2, net back value is -55 USD/1000 m3 gas sales. This means it is better to inject gas for more condensate production or to find another market or not to make any investment A more optimistic szenario: If the average gas prices for EU is taken as 420 USD / 1000m3 and the unit gas production cost for western Turkmenistan is taken as 120 USD / 1000m3, without changing the tariffs (hence the total investment costs of each pipeline are already optimistic values); then the new commercial summary table is given below. According to the results given in the table, netback values are better than the previous scenario however, for an investor it seems better to take part in a pipeline project instead of an E&P project. Moreover, for the most probable option (option2), again netback is minus. This means no positive decision for investment of Trans-Caspian.

	Transcaspian	AZ-TR Pipeline	Options			
			Option 1	Option 2	Option 3	Option 4
	75	85	110	130	0	125
Revenue			432	432	450	420
Netback			42	-13	90	45
All values are USD/1000 m^3 MOD prices						

Table 5: Evaluation of Commerciality - Netback Prices of the Scenarios (More Optimistic Scenario)

3.4 Results of the Evaluation

As a result the doability of Trans Caspian pipeline is not possible while the gas prices and EU demand will increase unexpected levels.

4. Trans-Caspian vs. Trans-Iran Pipeline

As seen in the chapter above, doability of Trans Caspian gas pipeline project is not possible due to commercial-political and market related obstacles in the current projections. However, some Iranian specialists claim that transportation of Turkmen gas through Iran to Turkey instead of Trans Caspian project will have better economics. In this chapter this claim will briefly be evaluated.

Map 4: Trans Caspian and Trans Iran Pipelines from Turkmenistan

4.1 Technical Proberties of Trans-Iran-Pipeline (Estimation)

- Start Point: Turkmenbasy / Turkmenistan
- End Point: Agrı / Turkey
- Total Length: 1442 km
- Operating Capacity: 30 bcma
- Inlet Pressure: 10 bar
- Outlet Pressure: 90 bar
- Pipe Diameter: 56"
- Thermal Isolation Material Quality: Middle Quality
- Estimated CAPEX (MOD): 16 billion USD
- Estimated Tariff (MOD) (%10 IRR based): 180 USD/1000 m3

4.2. Commercial Comparison

Hence the unit gas production prices in Turkmenistan and scenarios after the eastern border of Turkey are the same, total tariff values and total investments will be enough for comparison. As the calculation shown in the table below, Iranian transit of Turkmenistan gas will not be the economic choice.

	Trans-Iran-Pipeline	Trans-Caspian + AZ - TR Pipeline
Tariff @ TR Eastern Border (USD/1000m3)	180	75+85 =160
Total CAPEX @ TR Eastern Border (bUSD)	16	7+ 8 = 15

Table 6: Evaluation of Commerciality - Netback Prices of the Scenarios

4.3 Political-Market-Technical-Financial Comparison

On the other side, due to sanctions on Iran all political, financial and market related issues will be more risky and problematic than the trans-Caspian scenario. Only the technical milestones may be easier.

5. Summary

As described in the related chapters, gas politics and Caspian gas resources are very important energy security issues for huge consumers around the region. Turkmenistan by having the 3rd reserves potential and 2nd supply potential is the shining star of the region. That's why all huge consumers are planning and developing projects to meet some part of their gas demand from Turkmenistan resources. Such as extension of CAC Pipeline Project of China, TAPI Pipeline Project of India and Trans-Caspian Project of EU. For such huge pipeline project investments, long term projections, commerciality, politics, market views, and etc. are very important items to consider. There may be gas resources; however, if those resources cannot be transported to the market via a safe, sustainable and commercial way then, those resources do not mean anything up to the changes in the current conditions. That's why in this paper, with the risks and milestones, doability of the popular Trans-Caspian pipeline project is evaluated and as well as an alternative route to transport Turkmen gas to TR and EU through Iran is also compared. As a result, for the current situation, Trans Caspian pipeline project does not seem to be a logical choice for investment.

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ABREVATIONS

TR: Turkey
EU: European Union
CAC: Central Asia China
TAPI: Turkmenistan Afghanistan Pakistan India
CAPEX: Capital Expenditures
IRR: Internal Rate of Return
ACG: Azeri Chirag Guneshli Oil Field
MOD: Money of the Day
TANAP: Trans Anatolia Pipeline
TANAPX: Trans Anatolia Pipeline Extension
TANAPFX: Trans Anatolia Pipeline Forward Extension
SCP: South Caucasus Pipeline
SCPX: South Caucasus Pipeline Extension
SCPFX: South Caucasus Pipeline Forward Extension

Part 2 - Feeding biogas into the natural gas grid: challenges for the design, construction and operation of biogas feed-in plants – the example of Leizen

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Abstract

Despite general standardization of work operations and plant components, the respective plants for feeding biogas into long-distance gas transmission lines require an individual approach. Depending on which biogas processing plant is used in order to process bio-methane into biogas, the input parameters for feeding into the natural gas grid are different. The feed-in quantity, pressure and composition of the processed biogas that have to satisfy the minimum requirements of DVGW Worksheets Gas G 260 and G 262 thus correspondingly vary. On the exit side the location of the processing plant in relation to the gas grid, the pressure level and the nominal width of the gas pipelines determine the selection of plant components and their construction. Thus for the respective conditions the individual plant components have to be precisely dimensioned and matched to each other – in particular the key element: the compressor unit. Using the example of a biogas feed-in plant in the German federal state of Mecklenburg-Western Pomerania, the challenges of such a project – from the design to construction, all the way through to management – will be shown while presenting solutions for the specific requirements. What is decisive for smooth implementation of the project is constructive interaction between the power recipient, the transmission system operator, the implementing planning and construction companies, the suppliers of plant components and the approving authorities.

Introduction

Supplying processed biogas to the natural gas grid provides an important contribution toward the success of the change in energy policy in Germany. Every cubic meter of carbon-neutral biogas instead of natural gas in the grid improves its already favorable environmental balance. According to the industry barometer Biogas 2/2013 (Nov. 2013), a total of 130 biological gas plants with an annual feed-in potential of approximately 700 million cubic meters of biogas under normal conditions were connected to the German gas grid. However, while there has been an almost continuous increase in biogas connections in Germany throughout recent years, it is currently impossible to provide a forecast of further development. At present the German federal government is about to revise the past concept of feeding biogas into the natural gas grid as a contribution toward the change in energy policy. Nevertheless, for the operators of gas grids in Germany's new federal states the topic of biogas feed-in continues to prevail on a daily basis. As of March 2014 a total of 16 biogas facilities now feed their gas into the ONTRAS Gastransport grid alone. Thus this grid transports up to 135 million m^3/a of biogas under normal conditions on an annual basis – a quantity with which more than 115,000 households are able to be supplied for more than a year. And then there is also the biogas of numerous biogas feed-in facilities on the downstream grids. Since August 2013 the first power-to-gas plant feeds up to 360 m^3/h of hydrogen into the ONTRAS grid under normal conditions. Two further plants are currently under construction near Prenzlau and Grapzow.

Biogas generation plant (green fermenters) and biogas feeding plant (yellow building) Leizen inMecklenburg-Vorpommern, Germany.

Rules for Biogas Feed-in

Special rules apply when it comes to feeding biogas into the gas grid. Thus the processed biogas only has to satisfy the requirements of DVGW Worksheets Gas G 260 and G 262, 2007 version, while another minimum standard is binding for the grid operator with DVGW Worksheets Gas G 260/G 262 and G 685, 2013 version. Among other things, the latter defines the gas quality, the conditions for gas measurement as well as the calibration capability of gas measurements. The minimum requirements for the planning, production, construction, inspection and commissioning of a biogas feed-in plant are specified in DVGW Worksheet VP 265-1.

The essential components of a biogas feed-in plant include (Figure 1): a measuring and control line with an upstream filter and separator combination at the ingress point of the biogas feed-in facility – which is relevant for billing the power recipient and/or the biogas processor; the conditioning plant and the compressor plant. In addition there are components for the production of technological heat, for the production of control air and for closed-circuit cooling as well as a second gas measurement before actual feed-in into the gas grid In the measuring and control line the supplied gas quality and gas quantity are measured for billing the power recipient. In this case the processed biogas must comply with the limit values for hydrogen sulfide, nitrogen, carbon dioxide in particular. If necessary a conditioning plant adapts the calorific value of the biogas delivered as specified in DVGW Worksheet Gas G 260 to the calorific value of the gas grid using liquid gas (LPG) in accordance with the specifications of DVGW Worksheets Gas G 685. After that the gas delivered from the biogas processing plant with a specific delivery pressure is compressed to the required grid pressure. Several compressor stages may be required, depending on the pressure difference. What is also characteristic for the biogas feed-in plants at ONTRAS is a high degree of automation. All of the company's biogas feed-in plants are equipped for fully automatic operation without personnel. Constant monitoring performed by the dispatching headquarters in Leipzig. In addition, checks are carried out at monthly intervals. The minimum requirements for operation and maintenance of these plants are specified in DVGW Worksheet G 265-2.

Framework Conditions

The first biogas processing plant was connected to the ONTRAS grid in June 2009. Since then the statutory framework conditions have changed to the effect that since the year 2010 the grid operator is fully responsible for the grid connection as well as construction and operation of the feed-in facility and assumes the majority of the investment and all of the operating costs (cf. Biogas, Part 1, ptj 02/2013, Page 87 - 84). Moreover, in accordance with the German Regulations for Gas Grid Access [GasNZV] the grid operator must ensure operation of the feed-in facility for at least 96 percent of the proportionate annual hours. With the increasing number of projects that are to be realized and the concomitant operating experience the planning and realization of biogas grid connections have undergone constant further development. At the same time gradual standardization of the power supply concept took place. Thus, for example, among the first projects all of the essential assemblies were redundantly designed in order to ensure 96% availability for biogas grid connections. Today's plants have been optimized to such a degree when it comes to efficiency and costs that only the compressor plant is still redundantly built.

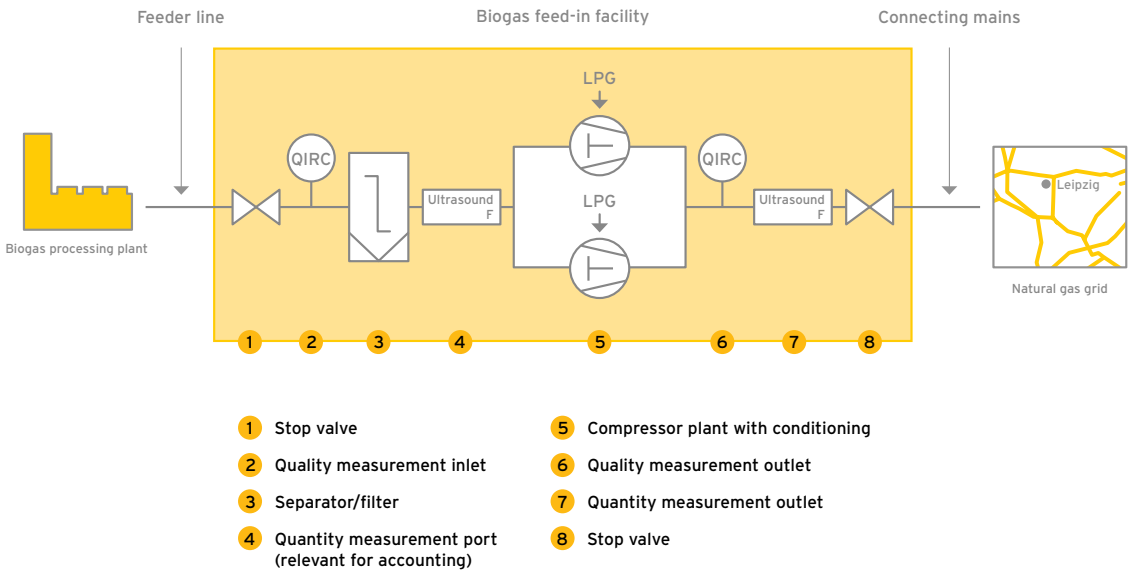

Figure 1: Schematic representation of a biogas feed-in facility

On the other hand, for example, the measuring technology is usually not duplicated due to the employment of targeted replacement value strategies. In order to be able to put a biogas feed-in plant into operation without a biogas processor ONTRAS has developed a mobile commissioning line, with the use of which agreed realization periods can be maintained or even shortened since commissioning is able to take place regardless of completion of the biogas facility. In the year 2013 the commissioning line passed the test with the Leizen biogas feed-in plant and has already been successfully deployed on several occasions since then. As a result schedules for committed technical crews in the projects are able to be maintained and the commissioning phase for power recipients shortened. Furthermore, the transmission system operator also invested in a mobile measuring line and a mobile compressor plant. If necessary they ensure, for example, that ONTRAS is able to ensure the prescribed availability in the case of prolonged maintenance work.

Process gas chromatograph and H2S detector of the biogas feeding plant Leizen.

Leizen Biogas Feed-in Plant

The signing of the connection agreement in May 2011 provided the starting signal for the Leizen biogas feed-in plant. From completion of the grid connection and use agreement through to commissioning, a total of 21 months were needed altogether for the planning and construction of the Leizen biogas feed-in plant. Thirteen months were required for the planning, collateralization, obtaining official permits as well as the invitation to tender, the ordering of components and their delivery periods. Although it often represents a critical point when it comes to building projects, the permits for the Leizen biogas feed-in plant were obtained without a problem. The building permit, the permit in accordance with the German Federal Emission Control Act (BImSchG) as well as notification as specified in the German Ordinance Regulating High Pressure Gas Pipelines [GasHDrLtgV] were assigned by the respective authorities without problems. Another seven months were required for civil engineering and building construction, plant assembly and the test phase for commissioning. A part of the construction work and the actual commissioning took place in the winter 2012/13 with snow and ice cold weather. This was the first time that the new commissioning line was used. The challenge for this pilot facility at the start was handling the pressure ratios of compression from 0.1 bar to 25 bar, which were new for ONTRAS. In addition, newly developed conditioning of the feed-in gas was employed for the first time. The plant was officially put into operation in February 2013. ONTRAS commissioned the Streicher Group as the general contractor with management and maintenance of the Leizen biogas feed-in plant. The maintenance coordinators of the ONTRAS North Grid Division is responsible for coordinating their work.

Operator of the biogas processing plant, power recipient	Biogas Müritz GmbH & Co.KG, Kassel
Biogas processing	MT-Energie GmbH
Processing method	Amine gas treatment
Feed-in of processed biogas (max.)	420 Nm^3/h
Delivery pressure/pipe diameter	0.1 bar/DN 150
Grid feed-in pressure/pipe diameter	25 bar/ DN 500

Table 1: Key figures

Key Element of a Biogas Feed-in Plant: Compressor Unit

Compressors for biogas feed-in plant are not products taken off the rack. The execution of such compressor plants is generally determined in substantial scope by the Renewable Energy Sources Act [EEG] and the specifications of the German Association of Gas and Water [DVGW]. The requirements to be met by the gas quality as specified in DVGW Directive G 260 are also relevant. These plants differ from the customary standard concepts through the stipulation of emission-free operation and the requirement of 96% availability throughout the year. The extremely variable operating conditions of biogas feed-in plants determine which materials are to be used in each case and require a high measure of experience when it comes to developing the technical concepts. The variances play a decisive role with regard to pressure, temperature and gas quantity.

Compressor unit oft the biogas feeding plant Leitzen with Prolimix gas conditioning system

Among the useful compression principles the reciprocating piston compressor has established itself as the machine that obtains optimum efficiency in the interaction of the requirements for the compression of processed biogas. Thus in energetic terms the reciprocating piston compressor is able to automatically adjust itself in optimum fashion to the variable pressure conditions of the biogas feed-in plants. Its operating principle ensures that efficiency is given almost independently of the play of pressure and the gas quantity supplied by the biogas processing plant. Thus it was not only for the Leizen biogas feed-in plant project that the company Neuman & Esser Group developed a compressor concept which is able to be individually modified for every biogas feed-in plant and complies with the respective contractually agreed grid connection terms and conditions at all times.

The compressor casing was implemented gas-tight for the biogas feed-in plant in Leizen. The design of the compressor plant ensures that oil-lubricated sections of the machine do not come into contact with the main gas flow. The drive system is designed for a low rotational speed level. Highly efficient compressor valves and a special biogas sealing material from the company Stasskol provide for optimum and economical operation. ONTRAS compressor plants for biogas feed-in plants are generally designed for fully automatic operation without personnel. To this end NEA in cooperation with the transmission system operator specified the safety requirements and implemented error-proof control. Thus the dispatchers at the dispatching headquarters in Leipzig are able to remotely view all of the available plant characteristic values at any time. In addition the buildings for the compressor plants are designed in such a way that servicing is possible under all weather conditions and without additional expenditure. This is the only way that the feed-in operation of an unmanned station can be guaranteed throughout the entire year. The compressor plants achieve operating cycles of more than 8,760 h (= a full calendar year) with the execution of the compressors optimized for the individual conditions in Leizen coupled with a low rotational speed level. The high resistance to wear and tear becomes clear using the example of an individual compressor piston: Each piston travels an approximate distance that corresponds to a threefold orbiting of the globe in one year before it has to go to maintenance. Apart from the pioneer facility in Leizen, ONTRAS has meanwhile deployed other NEA compressors for biogas feed-in plants.

Optimizing Gas Conditioning

In accordance with the experience gained by ONTRAS there are no known problems with the quality of bio-natural gas supplied by means of biogas processing. Regardless of the respective processing method the gas always satisfies the requirements of DVGW Worksheet Gas G 260. However, liquid gas (LPG) must sometimes be added to the gas flow for conditioning in order for the gas quality of the biogas obtained from the biogas processing plant to also satisfy the higher measurement and calibration requirements when it is supplied to the gas grid. A new method for mixing in the liquid gas is used in Leizen in order to optimize the conditioning process even further. With the Prolimix method developed by Scharr Tec GmbH & Co. KG and employed in cooperation with the compressor manufacturer, a biogas temperature of 40°C after intermediate compression already suffices in order to safely evaporate the liquid gas. In contrast the temperature has to be at least 70°C using the conventional method of external evaporation of the liquid gas and gaseous admixture to the biogas flow.

However, an additional heat source and thus additional expenditure of energy would then be required. In Leizen this was taken a step further: In cooperation with the compressor manufacturer the Prolimix method was employed directly after the first compressor stage. As a result of the compression the biogas is warmed up to approximately 105°C. The injected propane evaporates and thus cools down the biogas. This represents a twofold savings in terms of energy because no preliminary heating is required and the evaporating propane freely contributes to the cooling of the biogas. A further advantage of this gas conditioning consists in the avoidance of undesired enrichment of the gas mixture with propane through high pressure injection which stops immediately with interruption of the biogas flow. In the case of the conventional admixture under high pressure the retrograde condensation in the gaseous phase lines repeatedly causes substantial deviations in the calorific value.

The potential of this method which was enhanced even further in the weeks that followed was evidenced already at initial startup. As a result up to 40,000 kWh of technical heat per year can now be saved compared with a conventional evaporator system. Furthermore, this new method exhibits minimum susceptibility in standby mode compared with other evaporator systems which in part have to be taken out of service by on site personnel. Meanwhile ONTRAS has also installed this gas conditioning system in other biogas feed-in plants. ONTRAS obtains substantial savings through conditioning that is both customized and cheaper in terms of energy along with remote control of the calorific value from the dispatching headquarters in Leipzig.

Particularities of Measurement Technology

In general the expenditure and the overall measuring concept for biogas feed-in plants hardly differ from those of a gas measurement and control system at a normal grid connection point for natural gas with a large quantity throughput. However, there are several particularities that are specific to biogas. Thus, for example, gas analysis technology that is also able to detect and measure components typical to biogas, such as hydrogen and oxygen, must be used in a manner that is reliable and calibrated. At the biogas facility in Leizen a gas chromatograph from the company Marquis is employed. This gas chromatograph is based on a standard gas chromatograph from Siemens. Together with Siemens and in accordance with specifications from Marquis the analyzer was adapted to the particularities of biogas and is sold by Marquis under the name SAMBio. Here SAMBio performs continuous and sequential analyses of biogas and conditioned bio-natural gas using two separate measuring gas flows. Calibrated measurement of up to nine gas components is possible with this device. With very short analysis periods of approximately 200 seconds per analysis it also automatically monitors the legally prescribed limit values of the nine individual components as well as the calorific value and the standard density. The device also has an automatic optimization function for the method parameters.

In order to determine the gas quantity ultrasonic gas meters (FlowSick 600) are used in combination with calorific value quantity converters (FlowComp F1) at the biogas feed-in plant in Leizen. The essential advantages of this modern volume measuring technology are that they are mechanically insensitive when it comes to the pulsation of compressors on the one hand. On the other hand feed-in is not interrupted in the event of meter failure. A meter calibrated at low pressure is used in order to measure the biogas and a meter of the same design tested with high pressure is used for measurement of the conditioned biogas. With the log link to the calorific value quantity converter remote diagnostics of the ultrasonic gas meter can also be performed.

In order to take the requirements of the conditioning concept into consideration, the liquid gas quantity has to be measured already in the liquid phase. For this reason the consumption of liquid gas for conditioning the bio-natural gas is measured using a Coriolis flow meter and calorific value quantity converter with special-purpose firmware. Monitoring of the water content is carried out by means of a standard device (HYGROPHIL F 5673, Bartec). The special feature of this measurement is a quick-change system that makes it possible to remove the sensor under gas pressure. If the sensor is heavily contaminated with water, then it is possible to remove the sensor and wait without having to relieve the pressure on the pipe system. The water content of the gas can be calculated from the dew point in milligrams per cubic meter by means of integrated measurement of the gas pressure and gas temperature.

A separate analyzer (AmeteK) constantly monitors the hydrogen sulfide content in the gas. In this case the hydrogen sulfide content is measured through the absorption of ultraviolet light. The analyzer produces up to six discrete wavelengths for the analysis. A booster pump for the measuring gas designed particularly for the application provides for constant conditions in the measuring chamber. With approval for use in areas subject to explosion hazards the analyzer can be set up in the measuring chamber without any other special measures being required. All of the measured values are transferred online to the ONTRAS process control system. The gas quality measurement and the gas quantity measurement can be remotely queried and monitored via modem. With this special link the measuring technology can be easily diagnosed in the case of disturbance and troubleshooting measures can be promptly taken in order to provide a remedy.

Input and output rail of the biogas feeding plant Leizen

Particularities in the Operation and Maintenance of Biogas Feed-in Plants

With the increasing number of biogas feed-in plants in operation, the amount of overall support increases as well. ONTRAS staff also have to deal with this in spite of ongoing planning and new construction projects for additional plants. The approach that is used follows a concept that was successfully introduced even before the current unbundling; that is, management support through third parties, whereby service providers are commissioned with essential tasks on behalf of ONTRAS. If necessary they in turn commission respectively qualified, expert service providers for subtasks that are specific to plant components. Thus the maintenance coordinator of the transmission system operator is able to concentrate on coordination and monitoring the work assignments.

A high value is place on safety. Thus all of the specialists employed in field service are provided with hydrogen sulfide detectors and the protective agents appropriate to their tasks. Although hydrogen sulfide does not play a role when it comes to biogas feed-in plants, it could theoretically be released in the case of a disturbance when raw biogas is produced and processed in the biogas facility.

In order to not only ensure the legally prescribed 96% availability of the plants, but to also be able to verify such at all times any disturbances that have occurred in the biogas feed-in plants and their causes are recorded, evaluated and archived in a database. The biogas feed-in plant process data management (BEPDM) program which was specially developed together with IBZ Ingenieur GmbH fulfills the following functions: The process data from all ONTRAS biogas feed-in plants are centrally archived in duplicate for up to approximately 10 years. The availability of each plant is determined and verification of such maintained. The archived data allow for central data analysis of the process data and the process measurement data (trend system). With the help of BEPDM data conflicts and disturbances at the station computer can be detected. In addition the database also allows for centralized energy data management for management of the biogas feed-in plant. Moreover, all of the documentation for the ONTRAS biogas feed-in plants takes place in this system.

Summary and Outlook

As has been shown using the example of the biogas feed-in plant in Leizen, extensive standardization when it comes to the planning and construction of biogas feed-in plants has paid off; however, natural limits are reached due to the differing requirements for each system. It also makes sense to employ perfected, high-quality technology. This makes operation possible without personnel as well as continuous remote supervision and also helps to minimize subsequent costs. As was the case for the biogas feed-in plant project in Leizen, optimum project planning is also crucial for other biogas feed-in plant projects. This succeeds when all imponderables are jointly detected and solved by the project participants. What is particularly important is early, close and continuous contact with component manufacturers and suppliers as well as approving authorities so that in the end planning, delivery periods and construction measures are able to take place in the intended order and within the time allowed. Specially developed mobile units for commissioning, measurement and compression also help to avoid possible delays and partly even reduce deadlines. How the supply of processed biogas into the gas grid will continue to develop depends on the political framework conditions and the degree of acceptance of biogas processing among the public. If the German federal government succeeds in pushing through its new energy concept in the form currently presented – according to which the processing and feed-in of biogas would no longer be subsidized – then this would spell the end for many projects that are presently still in the initial stages. The originally specified target in the energy concept of the German federal government of up to ten billion cubic meters of biogas being supplied to the gas grid by the year 2030 would no longer be achievable. With threatening elimination of a further carbon-neutral biogas supply, another pil lar of support for the change in energy policy would topple as well. Every cubic meter of biogas instead of natural gas in the grid improves its already good carbon dioxide balance.

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Smart CCP – detecting minor damages in the coating of cathodically protected buried pipelines

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Abstract

Cathodic corrosion protection (CCP) is a technical system which is used to reliably protect underground steel pipes against external corrosion. For high pressure gas pipelines of public gas supply with an operating pressure > 4 bar, the installation of this protection method is even stipulated. Remote monitoring systems are used to check the effectiveness of CCP based on measurements. The generated data can also be used to assess the condition of cathodically protected pipes. The remote CCP monitoring technology used at present has been designed to collect tho measurement parameteres which are required to prove the effectiveness of CCP and send the information as raw data to the evaluation centre. This technology, however, is not suited for a permanent monitoring of cathodically protected pipelines. For a continuous monitoring, a new technology has to be applied which generates a constant stream of CCP measurement data at a high sampling rate which is processed and evaluated in situ, so that only relevant information will be transmitted to the evaluation centre. This technology, which is innovative in the field of CCP, is called online monitoring. The motivation to advance remote monitoring technology to an online monitoring is to detect possible external impacts which may be dangerous to pipelines early, and avoid catastrophes, such as the severe gas accident on 30 July 2004 near the town of Ath in Belgium. Online monitoring is capable of detecting dangerous external impacts, such as for instance from an excavator bucket, on buried pipes with cathodic protection, and promptly transmit a danger alarm.

Current technological level of remote CCP monitoring

The current remote CCP monitoring technology meets the requirements stipulated in Code of Practice GW 16, cf. German Technical and Scientific Association for Gas and Water DVGW, GW 16 "Cathodic Protection (CP) of Buried Storage Tanks and Steel Pipes – Remote Monitoring" (2008-05). Typically, the measurement values are interrogated up to four times a day, while the data is transmitted once a day to the evaluation centre via SMS through the mobile communications network. The CCP technical staff in the control centre evaluate the received measurement data, as shown in Figure 1.

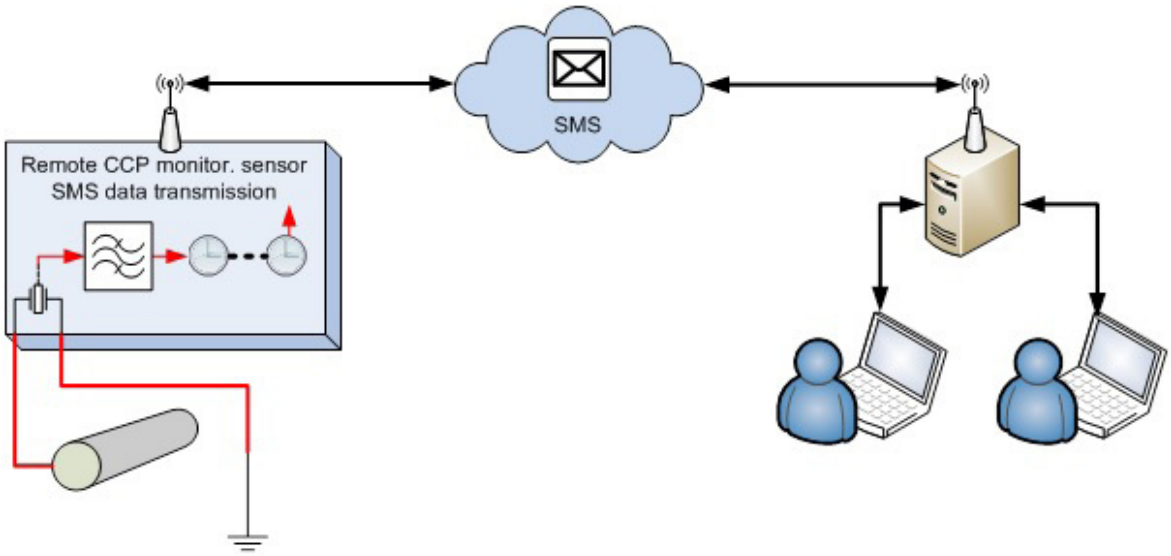

Figure 1: Current technological level of remote CCP monitoring

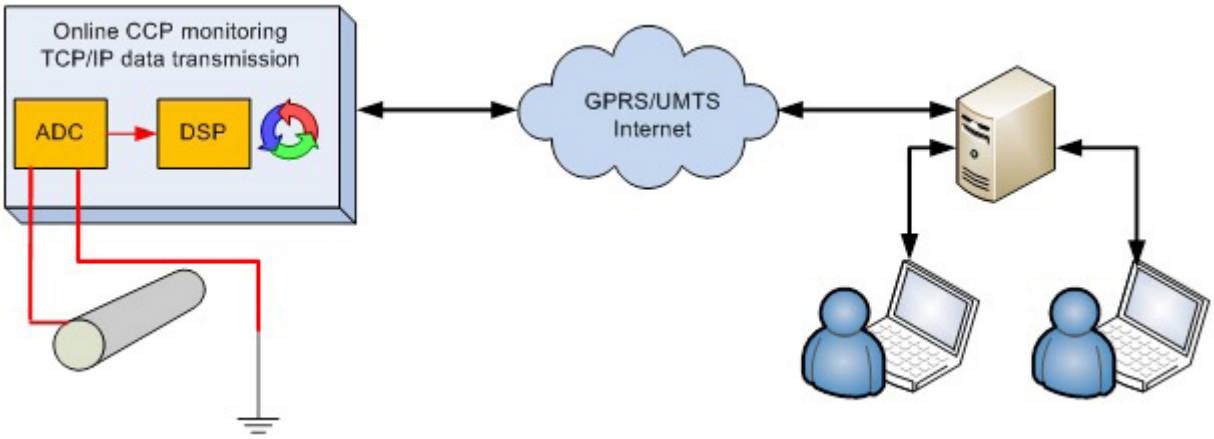

Figure 2: Online monitoring

The system does not allow to interrogate and evaluate the measured data on a non-stop basis. Neither is it possible to directly process measurement data with an insitu sensor in order to automatically analyse the measured values for irregularities or specific events. Remote monitoring technology has been designed to collect the key CCP measurement values at larger intervals (at least once a day) and transfer them to the control centre where they are compared to reference values. For the maintenance strategy of pipeline operators, information about the condition of their networks is indispensable. Evaluating the effectiveness of CCP and the coating quality of a cathodically protected pipeline provides meaningful evidence about its condition. However, the existing remote CCP monitoring technology cannot reliably detect events, which change a pipe's coating resistance only for a short time and cannot be tracked over a longer period, but may well be critical referring to its integrity. To make matters worse, the existing online monitoring technology can only poorly detect external impacts, which – compared to the ground resistance of a pipeline – are high-resistance, or not at all.

Online monitoring: General remarks

Online monitoring represents a new concept of remote CCP monitoring. It is based on an uninterrupted collection of measurement data with a much higher resolution of value and time domains, allowing for an accurate digital mapping of the CCP measurement values, including their curves. This is followed by an evaluation of the measured data with methods of digital signal processing. By implementing algorithms in the CCP sensor software, it is possible to adapt the computation to specific tasks and ambient conditions. The direct data processing in the sensor allows for a smart evaluation of the measured data based on defined criteria. If a specific event to be detected occurs, such as for instance damage from an excavator bucket, the data will be transmitted instantly as alarm to the desired receiving station. Online monitoring represents a non-stop monitoring of key CCP measurement parameters, such as the ON potential. In combination with the continuous collection of other measurement data, which will also be possible then, such as AC voltage induced on the pipeline by external sources like high voltage power lines, statements on the condition of cathodically protected pipelines will become more precise. What's more, it is now actually possible to detect short-time and possibly dangerous external impacts on a buried pipeline (from an excavator bucket for instance). In order to measure impacts of this type, a much more sensitive and faster technology than the one used so far is required. To ensure that the CCP sensors can be accessed any time and that the sensor data can also be transmitted to the control centre any time, an appropriate communication structure needs to be implemented. The existing remote monitoring sensors transmit data via SMS transfer, a method which is not suitable for a data transmission deterministic in time. In contrast, data transmission based on the TCP/IP protocol, as it is realised in Ethernet networks, on the Internet and via GPRS/UMTS in mobile telecommunications, is well suited for this task. Figure 2 sketches the method.

Online monitoring: Technology

The major differences of the new online CCP monitoring technology compared to the existing remote CCP monitoring technology are measurement data collection and processing and data transmission/communication.

Collection of measurement data

A prerequisite of online monitoring is that the CCP measurement values are collected without loss of information for further processing. The information content of the measured signals always relates to the context of the task to be solved or the shares of a signal in the measurement signal which need to be recorded loss-free in order to evaluate them in the later signal processing. In order to process physical parameters in a processor, the information has to be digitised via an analogue-digital converter, differentiating between the value domain and the time domain. The resolution of the value domain, specified in bits, needs to be adapted to the measurement range and the smallest amplitude variations to be recorded. The resolution of the time domain determines the upper repeat frequency up to which it is possible to record the continuous measurement signal without losing signal changes during digitisation regarding time.

The sampling rate of the continuous signal when digitising to a discrete-time signal determines the frequency up to which the signal can be reconstructed in the processor. The Nyquist-Shannon sampling theorem has to be considered for the dimensioning of the analogue-digital conversion. This theorem states that the frequency with which the continuous measurement signal is sampled, i.e. digitised, must be at least twice as high as the highest frequency which occurs in the measurement signal to be recorded. This is the mathematical, theoretical requirement for a full reconstruction of the desired signal after it has been digitised. In its technical application, however, the sampling frequency needs to be increased by a multiple in relation to the sampling theorem to ensure a safe signal recording. The sampling rate is often stated in Hertz or values/s. The values measured by the online CCP monitoring are converted from analogue to digital with up to 1 MHz, which means that the course of the CCP measurement values is digitised with 1 million values per second, generating a very precise mapping in the processor. Analysis has shown that sampling rates of this magnitude are required for a safe detection of impacts with a very short-time effect, as they occur when a pipe is damaged by an excavator bucket. Figure 3, 4 and 5 illustrate how the quality of digitising an analogue measurement signal depends on the sampling frequency. Figure 3 shows the analogue input signal. Figure 4 and 5 show the sampling of the signal with an analogue-digital converter, where the red lines indicate the moments when the values were captured. The resolution of the value domain is high which is why no information is lost. In Figure 4, the resolution of the time domain in relation to the time of signal change is not high enough, i.e. the sampling frequency is too low to digitise the signal without loss of information. As a result, the high-frequency change in the signal is not detected. Figure 5, in contrast, shows that the high sampling frequency records the high-frequency oscillation so that it is mapped in the digitised signal.

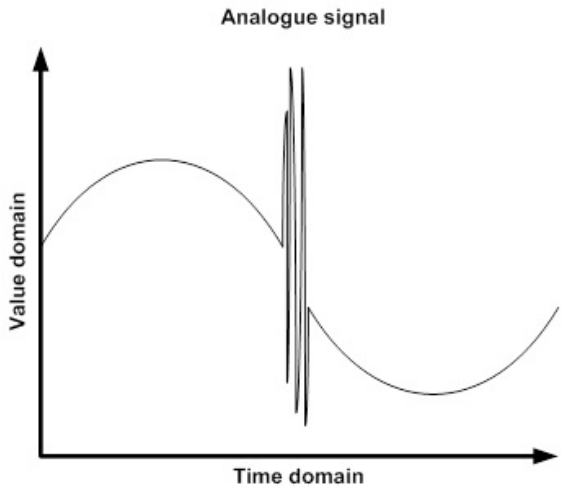

Figure 3: Analogue signal

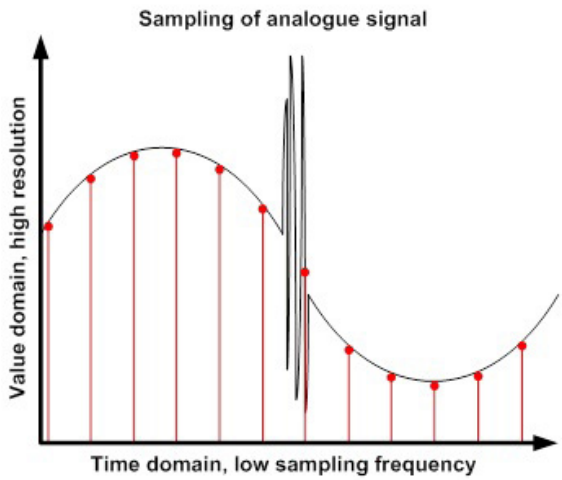

Figure 4: Sampling of the analogue signal of Figure 3 with low sampling frequency, high-frequency signal shares are not recorded

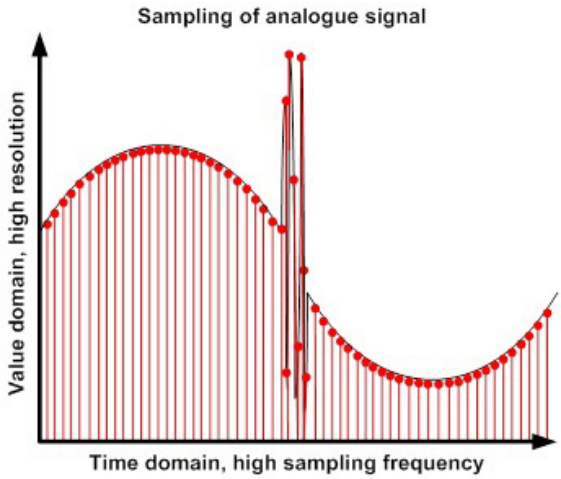

Figure 5: Sampling of analogue signal of Figure 3 with high sampling frequency, all signal shares are recorded

Processing of the measurement data

In a next step, the digitised measurement values are evaluated with computations. Online monitoring with its simultaneous and continuous collection of multiple CCP measurement parameters puts special demands on the performance of signal evaluation. A digital signal processor with special software algorithms and methods of digital signal processing is used for the automatic and simultaneous processing of all measurement values. By implementing appropriate software algorithms and a non-stop evaluation of voltages and currents on a pipeline, specific signal patterns, like that generated when hit by an excavator bucket, can be detected automatically. The computation of the individual CCP measurement parameters can be requested at virtually any time. Apart from the protective current supplied by the protective current unit, the measured voltages and currents also contain interference signals, induced into the pipeline by, for instance, high-voltage overhead lines or AC voltage railway tracks. The demands placed on online monitoring call for a recording of all components contained in the measurement signal (interference signals as well as the shares of the CCP protective current) without the use of hardware filters. This is necessary for a safe splitting of the interfering influences from those shares of the signal which are relevant for the specific evaluation and determination of the measurement parameters and the events to be detected using statistical methods.

The Fourier analysis is appropriate for signal processing tasks of this type. This analysis transforms the signals of the time domain to the frequency domain where they are analysed. Using methods of frequency selective analysis, the signal components can be investigated isolated from each other to allow for a focused examination of their changes. To analyse the continuously collected CCP measurement data, the Fourier analysis needs to be applied to permanently refreshing data. When the Fourier transform is applied to a dataset, the time information is lost since the complete dataset is broken down into its frequency shares, and the associativity of an occurring frequency to a specific point in time is lost. To avoid the loss of time information, the so-called short-time Fourier transform is applied. The Fourier transform is applied to equidistant time sections whose results are examined with their correlation of time. In this way, continuously refreshing time signals, as is the case with the non-stop recording of the CCP measurement parameters, can be analysed in the frequency domain. Figure 6 illustrates the application of the short-time Fourier transform to a time signal. The time signal is multiplied by a window function, and this window is then Fourier transformed. The window function runs over the complete time signal, displaying the amount of the respective frequency shares in relation tothe respective point in time as shown in Figure 7.

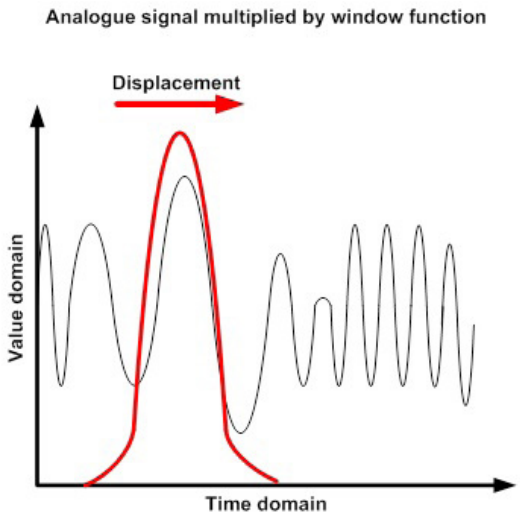

Figure 6: Analogue signal multiplied by a window function for the short-time Fourier analysis

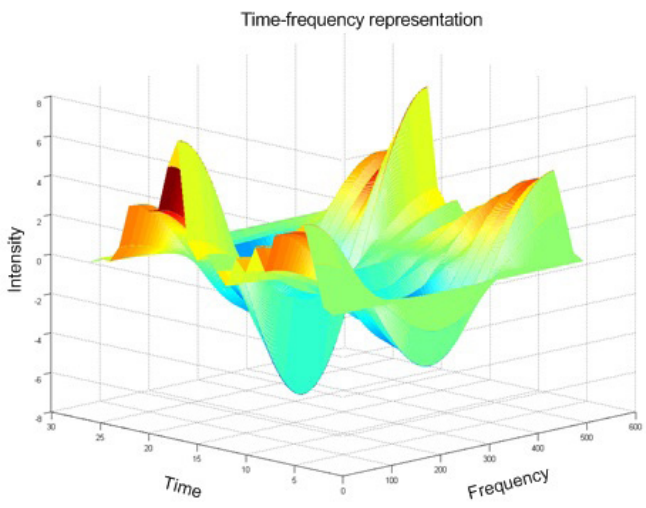

Figure 7: Time-frequency representation of the analogue signal

The measurement values transformed to the frequency domain are then evaluated with more algorithms in order to detect irregularities and meaningful characteristics in the curve of the measurement signal. Based on the patterns of these signal curves, it shall be possible to detect impacts, such as by an excavator bucket. By realising an evaluation solely based on software algorithms, the system remains very flexible. Evaluation methods for future requirements can be implemented by installing software updates, which allows for an easy expansion of features based on the same hardware system.

Data transmission/communication

The CCP sensors for online monitoring are connected to the control centre via the so-called packet data transmission of the TCP/IP protocol. The bidirectional data transmission and communication allows for high transmission rates and establishes a permanent connection among all participants, so that the interlinked systems can exchange data any time. The TCP/IP protocol is the basis in Ethernet networks, on the Internet and the GPRS/UMTS standard in wireless communication. The physical transmission channel used for the communication is therefore irrelevant for the provision of information. The telecontrol protocol IEC 60870-5-104 used in control systems, which is published as DIN EN 60870-5-104 "Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC60870-5-101 using standard transport profiles (IEC 60870-5-104:2006)" (2007-09), is also based on TCP/IP, so that the smart CCP sensors can also be integrated in a control system. For communication and data transmission and to perform open and closed loop control processes of the protective current unit, the license-free Linux operating system is used Future possibilities of CCP through online monitoring.

Online CCP monitoring takes full advantage of the information content provided by the CCP measurement parameters. Based on software algorithms, the digital signal processing processes the measurement data and evaluates them based on specific parameters and occurring events. This al-

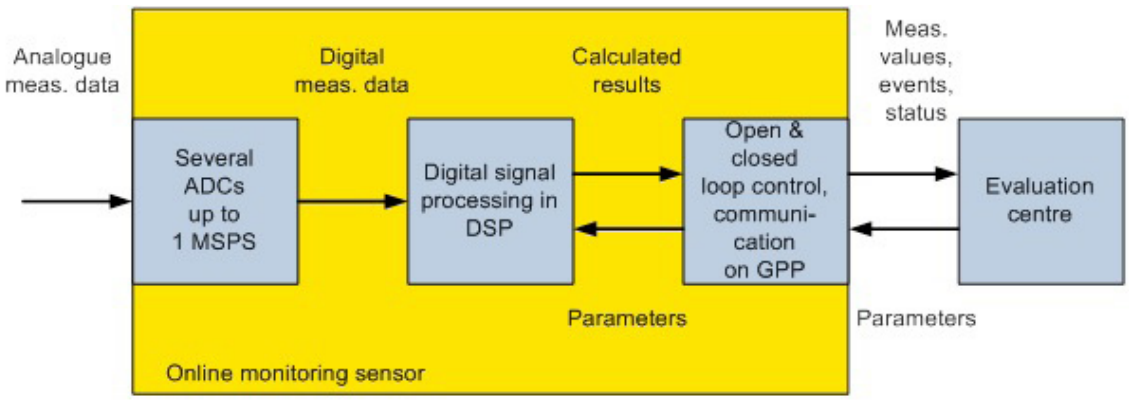

Figure 8: Schematic illustration of the structure of the online monitoring sensor, based on the implementation of the system features as mere software modules

lows for an easy adaptation of the system to changing situations and requirements by simply modifying the software. Figure 8 sketches the structure of the system, based on the implementation of features as mere software modules. Signal processing takes place in the digital signal processor DSP, while the general open and closed loop control and communication tasks are performed in the second processor GPP (general purpose processor). With the fast and universal connection of the measuring sensors to the control centre via communication channels based on the TCP/IP protocol, it is possible to transfer measurement information, safety messages or control commands with a high transmission rate at any time without relevant delay.

Continuously adjustable output voltage of a protective current unit

With the new technology, it is also possible to perform precise open and closed loop control functions to allow for a fast and continuously adjustable setting of the output voltage of the protective current unit for instance, based on the processing of the measured values. In future, such control algorithms will certainly be required on pipelines which are subject to AC voltage in order to minimise the risk of possible AC corrosion. Related research results can be found in the DVGW research project G 2/01/08 on field tests for testing the influence of AC voltage and ON potential on AC corrosion.*

Reducing operational costs

Great portions of the operational costs of CCP are also influenced by the quality of remote monitoring. The less often the insitu monitoring measurements stipulated in the DVGW Code of Practice GW 10 "Cathodic Protection (CP) of Buried Storage Tanks and Steel Pipes – Commissioning and Monitoring" (2008-05) are required, the better the operational costs for CCP can be optimised. GW 16 formulates both the requirements placed on remote CCP monitoring in relation to the selected remote monitoring category and the respective possibilities to reduce insitu measurements.

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With online CCP monitoring, an economic installation of a remote monitoring process according to GW 16 Category 2c, and thus the possibility to completely do without in-situ measurements according to GW 10, is again within the range of possibility. Extensive test measurements which were carried out in our premises have shown that this measurement technology was also able to safely detect the occurrence of new coating defects, whose ground resistance was 100 times higher than the coating resistance of the pipeline section (note: GW 16 merely stipulates a factor of 15). Figure 9 shows the electrical equivalent diagram of this situation.

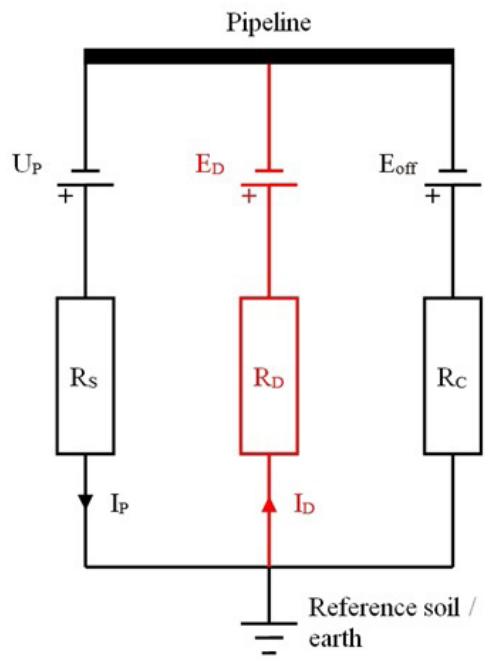

Figure 9: Electrical equivalent diagram for a cathodically protected pipeline with additional, temporarily effective coating defect with relatively high resistance modules

I_P	=	Protective current without new coating defect
U_P	=	Output voltage at protective current unit with out new coating defect
R_S	=	Spread resistance of anode system
U_{off}	=	OFF potential in the pipeline without new coat ing defect
R_C	=	Coating resistance of pipeline without new coating defect
R_D	=	Spreading resistance of new coating defect
U_D	=	Potential of new coating defect
I_D	=	Current to new coating defect

Danger prevention

The key innovation of the online CCP monitoring technology is the possibility to prevent danger on cathodically protected buried pipelines, which has been made possible by detecting even the smallest external impact on a pipeline. In general, the person who damaged a high pressure gas pipeline with gas leakage will notice and report this event. If, however, there is no gas leakage, but the external impact leads to a mechanical weakening of the pipeline, problematic situations may occur later. In the latter case, it is particularly important that the operator is informed about such an external impact so that appropriate countermeasures can be initiated.

Summary

In the field of CCP, the new online CCP monitoring of cathodically protected pipelines represents a ground-breaking innovation. With the continuous monitoring of important CCP measurement parameters, dangerous external impacts on pipelines, such as from an excavator bucket, can be detected promptly. These external impacts are detected and sent immediately as danger alarm, even if they did not cause an apparent destruction of the pipeline. External mechanical impacts, in particular, which do not lead to an instant gas leakage, cannot be recognised with usual measurement technologies. Up to now, network operators have to rely on that the respective person notices and reports the damage.
What's more, a detailed evaluation of the CCP measurement parameters, in combination with an improved protective current unit technology, allows for a continuously adjustable control of the CCP protective current in order to counteract possible dangers through AC corrosion. With the fast and permanent integration of the CCP sensors to the control centre via standardised transmission protocols, as they are used in networks, wireless communication and on the Internet, information from and to the sensors can be transmitted between the systems any time. The implementation of online CCP monitoring will help to significantly reduce the operational costs of CCP, since it makes an economic installation and operation of remote CCP monitoring according to Category 2c feasible in many cases.

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Nove High Performance Polyurea Spray Coatings for corrosion protection

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Abstract

Long-term exterior corrosion protection of buried pipelines is crucial for safety, performance, and cost of pipeline operation. There is normally more than one corrosion barrier applied to pipelines. Cathodic Protection (CP) inhibits steel oxidation by creating an electrochemical cell vs. ground potential. In addition, polymeric coatings protect from oxidation by preventing direct contact of soil, water, or air with the steel pipe surface. Coatings used in the past often did not yield the design lifetime of, e.g., 40 years. Salt marsh soil, named "Subkha" in Arabic, provides a particularly challenging environment for buried pipelines. Subkha soils, found in coastal areas around the world, are sandy soils with high water and salt contents. Novel High Performance Polyurea spray coatings were developed that come close to being an ideal coating material for Subkha soils. These materials possess a high resistance to Subkha conditions, a very strong bond to the steel, and the shortest possible application and curing time. Hence, they are ideally suited for rehabilitation of aged pipelines in Subkha soils.

1. High performance elastomer coatings

Elastomer: "A formation of a thermoplastic or thermoset that can stretch and then return to its original shape without permanent deformation".

Polyurethanes and polyureas are elastomers with properties that are very much suited for pipeline protection. The principles of polyurethane and polyuria are shown in figure 1.

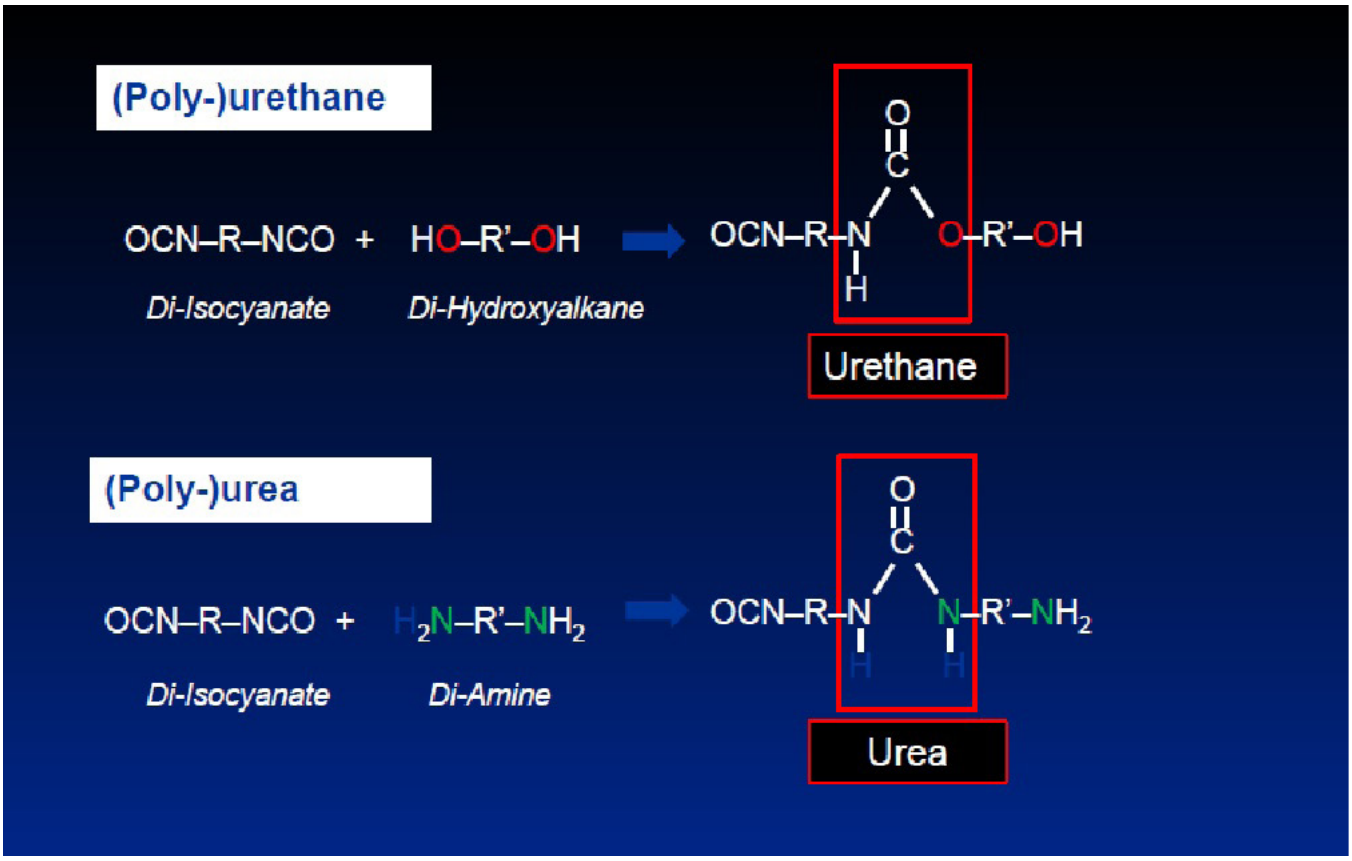


Figure 1: Polyurethane and Polyurea

Besides the two main components shown in figure 1, there are 5 to 8 components involved in manufacturing a polyurethane or polyurea elastomer. Except for the di-isocyanate component, all other ingredients come in hundreds of varieties each. Taking into account that a wide array of reaction conditions and mixing ratios is possible, the chemistry that yields polyureas and polyurethane allows for permutations reaching into the hundreds of thousands to millions. Each of these permutations will yield a material with unique properties. Products with properties that outperform the property profile of commercially available polyurethanes and polyureas are termed "High Performance Polyurethane (or Polyurea) Elastomers". Both High Performance Polyurethanes and High Performance Polyureas exhibit extraordinarily strong adhesion to metals and are hence suited for application as internal or external pipe coatings. The short tack time of polyureas makes these materials very suited for spray application.

2. Corrosion protection of buried pipelines

Regardless of the type of soil, buried steel pipelines are always prone to corrosive attack. CP alone is not sufficient for long-term pipe protection in most cases. Issues from lack of maintenance of the electrical system, insufficient replacement of sacrificial anodes, and others contribute to a reduction of the protective effect of CP over time. Since the early days of modern pipe laying in the middle of the last century, additional protection was achieved by wrapping or coating the outside of the pipe with a non-metallic material. Bituminous wrap, polyethylene wraps or coatings, and various grades of epoxies, polyethylene, or FBE (fusion-bonded epoxies) were and still are being used. Over the years, improvements in these coatings were made, from cost saving application methods to coatings with improved properties. On average, a pipeline life of 40 years was designed; today, many pipelines that are 20 to 40 years old (or older) show corrosion issues indicating that neither CP nor the coatings used in the past did completely prevent corrosion. In the past, external corrosion of coated pipelines was often hard to detect if corrosion under the coating (CUI, corrosion under insulation) occurred. In recent years, improved inspection methods, particularly the use of inline inspection (ILI) tools employing Electro Magnetic Acoustic Transducer (EMAT) technology, have made it possible to pinpoint CUI and coating disbondment with high accuracy by running an ILI tool through the pipeline. Since ROSEN introduced EMAT into the ILI market in 2006/2007, some large operators have found that a significantly higher than expected share of their buried pipes exhibit issues of coating disbondment. Often before they reach their design life. The need to save such pipelines from severe corrosion damage plus the strong demand to extend original design life of buried pipelines has led to a renewed push to develop exterior pipe coatings that

- are designed to last 40 years or more when buried,
- are binding to the pipe surface strongly, and
- can be applied as refurbishment on existing pipelines after removal of the original coating

3. Subkha

Subkha is the Arabic name for sandy salt marsh areas, often desert sand above a high salty ground water level which often is exposed to tidal rise and fall of this level. Over a large stretch of the coast of the Saudi Arabian peninsula, such Subkhas prevail. But also on other continents, such conditions exist. Pipes buried in Subkha soil are generally exposed to a high salt content. With tidal and / or seasonal fluctuations, it often occurs that these pipes are at least partly, in some cases fully immersed in salt water over quite some time during the year.

4. Thrust boring

For road and river crossings, the building of tunnels for pipelines has mostly been replaced by thrust boring or horizontal directional drilling (HDD). In both cases, the pipe is pulled or pressed through the soil and remains in place afterwards. To enable a design life of thrust boring pipes that matches the rest of the pipeline, it is essential to protect the pipe from abrasion by rocks during the pressing/pulling process. A coating used in thrust boring must, however, also provide highest possible corrosion protection after it was laid.

II. High Performance Polyurea Spray Coatings for Subkha and thrust Boring

1. Polyurea Spray Coatings

Polyurea spray coatings have been in the market for a number of years, as have been polyurethane spray coatings and hybrids of both materials. To develop High Performance Polyurea spray coatings, ROSEN used the "building block" chemistry shown in figure 1 to create an optimum recipe that ideally combines very strong adhesion to steel, short tack and dry time, and long-term design life when buried in Subkha soil. Also, a type that exhibits extremely strong abrasion and tear resistance was developed.

Besides the recipe, two other factors are important for successful coating with these materials. One is the pipe preparation; grit blasting according to industry standards (e.g., 60 µm roughness) and complete removal of salts, particularly chlorides, is of utmost importance. The other is application in consistent thickness and quality. For thrust boring (short distances), the coating normally is applied in the factory. For Subkha, there is a big demand for pipeline rehabilitation which makes it necessary to apply the coating in the field. To reach highest consistency, the coating needs to be applied by machine and not manually. Also, the structure of the coating itself contributes to this consistency. Figure 2 shows the structure of a High Performance Polyurea spray coating. Spray coatings were developed that come close to being an ideal coating material for Subkha soils. These materials possess a high resistance to Subkha conditions, a very strong bond to the steel, and the shortest possible application and curing time. Hence, they are ideally suited for rehabilitation of aged pipelines in Subkha soils.

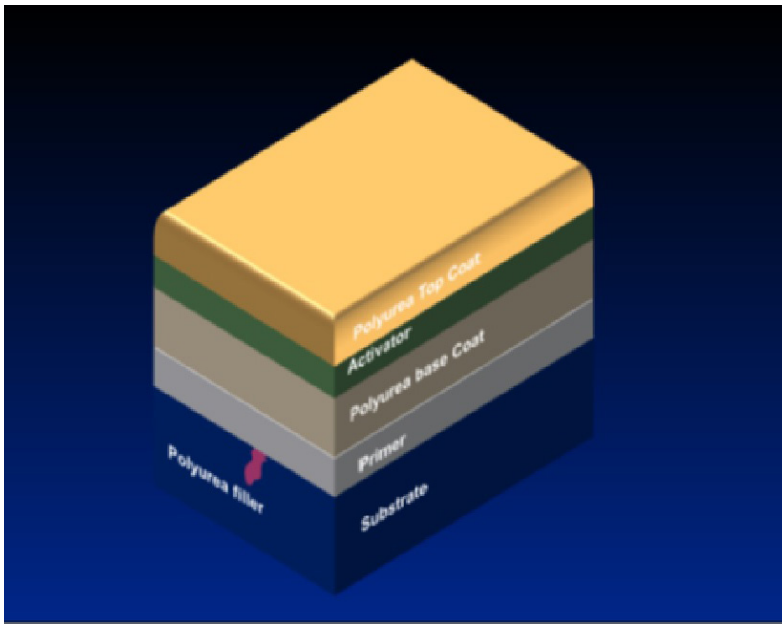


Figure 2: Structure of High Performance Polyurea spray coating

2. Laboratory Testing

There are a number of industry standards that apply to external pipe coatings; these are listed in figure 3. Before High Performance Polyurea Elastomer Coatings were introduced into field trials, a large number of laboratory tests was performed by certified independent laboratories. Particularly predictive tests for long-term buried life in Subkha soil. Independent laboratory test data can be obtained from the authors.

Figure 3: Industry Standards

III. Field Experiance

1. Subkha

In a field trial in Subkha soil running over more than a year, the High Performance Polyurea Elastomer spray coating RoCoat 230, developed specifically for this environment performed exceedingly well. No changes, blistering, or disbondment were observed after refurbishing an operating pipeline with RoCoat 230 and burying this pipe for 1 year in Subkha environment. Due to the small volume, this coating was applied manually.

To simulate an in-field repair of this polyurea coating, e.g., a situation where accidental mechanical coating damage due to excavation or construction activity occurred, over a small area of pipe, a hand-applied 2-component High Peformance Polyurea Elastomer repair kit (modified polyurea recipe to allow brush application) was applied and inspected half a year later. After 6 months, both the repair "patch" and the transition areas at both ends showed complete adhesion and full integrity, even under the very difficult conditions described under a) and b).

Figure 4: Subkha - the pipe before coating.

Figure 5: Subkha – the pipe after coating.

Figure 6: Polyurea repair patch

2. Thrust Boring

In a thrust boring trials, tape wraps and epoxy coatings as well as the specifically designed RoCoat 221High Performance Polyurea Elastomer coating were compared in a rocky desert environment. In the trial, the pipes were pushed through and received on the other side to assess the damage.

Whilst all other coatings showed significant damage from the thrust boring process, the High Performance Polyurea Elastomer did not. Figure 7 shows PE tape wrap vs. RoCoat 221 after the thrust boring process.

Figure 7: Thrust boring: PE Tape wrap vs. High Performance Polyurea coating

IV. Automated Coating Application

As stated earlier in this paper, reliable application of spray coatings over long distances requires an automated solution. For the strongly growing need of in-field rehabilitation of aged pipelines, such equipment will be applied a lot more than in the past.

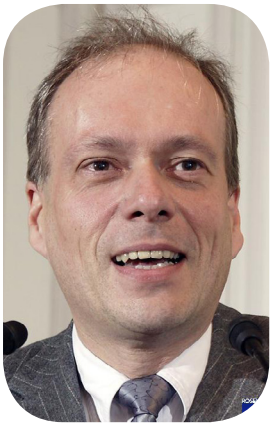
Equipment "trains" that can strip coating, wash and grit-blast the steel pipe, apply primer and finally apply the coating are available from less than a handful of suppliers globally. For polyurea as well as for polyurethane application, the requirements spray equipment has to fulfill are different from those for other coatings. Critical factors include the need to maintain an exact and constant mixing ratio of the components at the spray nozzle, the need to bring all components to the nozzle at a defined elevated temperature, and the issues associated with the significantly different viscosities of the components. An equipment train specifically for High Performance Polyurea Elastomer spray coatings was developed and tested. This equipment is now ready for commercial application.

V. Conclusion

High Performance Polyurea Elastomer spray coatings have passed predictive long term live time tests by international standards. These materials are particularly suited for salty soils and Subkha environment. A field trial over more than one year proved this.

Due to the very high abrasion resistance of polyuria coatings, they can provide ideal coatings for thrust boring / horizontal directional drilling where pipes are directly "pushed" through soil and can experience strong abrasive forces by hard soil and rocks. In first field trials, a specific "thrust boring recipe" of High Performance Polyurea Elastomer spray coating was successfully tested. No damage was found whilst PE wrap and epoxies showed severe scratches and damage. A repair kit for manual in-field repair of these coatings has been developed and successfully applied in the field, even in transition areas where complete surface preparation is not possible. Fully automated application equipment for multi-kilometer stretches of in-field pipe coating has been developed and tested successfully.

Authors



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an EITEP Event

Euro Institute for Information and Technology Transfer

Report - Pipeline Technology Seminar Middle East Dubai, United Arab Emirates, 25. / 26. February 2014

an EITEP Event

Euro Institute for Information and Technology Transfer

Besides the annual Pipeline Technology Conference in Berlin and the publication of the electronic Pipeline Technology Journal, the ptc organizer EITEP Institute offers a range of specialized seminars.

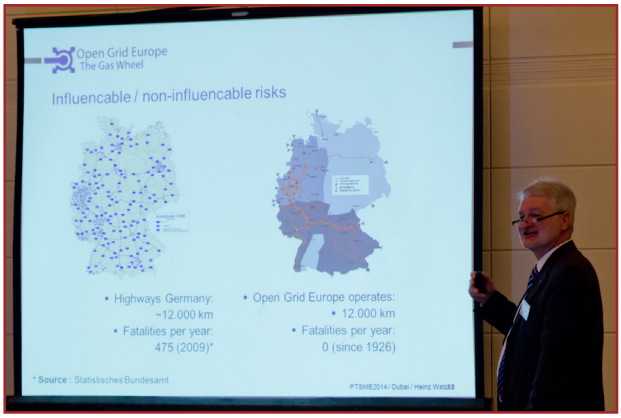
The first Pipeline Technology Seminar Middle East on "Pipeline Life cycle extension strategies (from a German operator's point of view)" was successfully held on the 25/26 February 2014 in Dubai, UAE at the kind invitation of Arabic oil and gas operators. The event had an ample amount of participants of 23 managers, technical experts and researchers attending from Saudi Arabia, Qatar, UAE, Germany and Italy.

The seminar was chaired by the course director Mr. Heinz Watzka, former Managing Director Technical Services of Germany's largest pipeline operator Open Grid Europe. In the 2-day seminar Mr. Watzka gave detailed technical input on innovative tools and techniques developed for a failure-free and economic operation and maintenance of high-pressure oil, gas and water pipeline systems sharing his long years experiences as an operator. He integrated different technical experts from NDT Global, Rosen Group, ILF Consulting Engineers, GE Oil and Gas as well as Geomagic who gave an insight into latest technologies.

Take a look!

You can receive further Information about upcoming Pipeline Technology Seminars in the Middle East from Rana Alnasir-Boulos at EITEP Institute, Phone: +49 511 90 99 2-20, Mail: alnasir-boulos@eitep.de.

The Emirate of Dubai is the second largest of the seven United Arab Emirates but has the biggest population at over 2.1 million inhabitants. Dubai is a global city, a business and cultural hub of the Middle East and the Persian Gulf region.



The Pipeline Technology Seminar was chaired by Mr. Heinz Watzka, former Managing Director Technical Services of Open Grid Europe

Detailed technical input for a failure-free and economic operation and maintenance of high-pressure pipeline systems was given

Experts from NDT Global, Rosen Group, ILF Consulting Engineers, GE Oil and Gas and Geomagic gave insights into latest developments

A total of 23 managers and technical experts from Saudi Arabia, Qatar, UAE, Germany and Italy attended to the first PTSME in 2014

International infrastructure and pipeline events 2014

May 2014

9th Pipeline Technology Conference (ptc)

12. - 14.05. Berlin, Germany
Europe's Leading Conference and Exhibition on New Pipeline Technologies.

September 2014

4th Issue Pipeline Technology Journal (ptj)

15.09. Pipeline Technology Journal covers reports about research, industry and practice, presentation of innovative concepts and technologies, latest information about pipeline conferences and other related event information.

October 2014

International Pipeline Seminar Week

tba. Hamburg, Germany
Topic: "Pipeline life-cycle extension strategies - new technologies in operation".

November 2014

Pipeline Technology Conference Seminar

14.11. Abu Dhabi, UAE
The Pipeline Technology Seminar (Middle East) will give an overview on the managerial and technical life-cycle of a pipeline system from the very beginning to the final daily operational works.

2nd. Infrastaructure North Africa (INA)

19. - 20.11. Tunis, Tunisia
International Conference and Exhibition for the Revitalization of the North African Infrastructure Market.

Topics: • Supply and disposal solutions • Production and treatment solutions • Transport and logistics solutions • Pipeline solutions

February 2015

ptc Middle East

tba. Kuwait, Kuwait
Conference and Exhibition on New Pipeline Technologies.

Pipeline Technology Conference, ptc, moves to Berlin

Having grown up as part of HANNOVER MESSE, Europe's leading pipeline conference and trade show, Pipeline Technology Conference (ptc), is moving to the capital Berlin this year taking place in the Convention Center of the Estrel from the 12th till the 14th of May 2014.

The ptc has grown steadily over the years and, in addition to the conference itself and the accompanying exhibition, it is now also directly followed by several special workshops and in-depth seminars. International participants from over 30 different countries use the opportunity to come to Europe and obtain information about cutting-edge technologies and new pipeline projects.

These issues are therefore at the heart of the technical sessions that, with approximately 60 lectures, make up the core of the ptc. Furthermore it will be followed directly by a series of detailed **workshops and seminars** that will run until Friday, May 16th. **During the last two days special seminars on Safety, Integrity and Reliability as an Integrated Pipeline Management System / In-Line Inspection of Transmission Pipelines / Geohazards and Geotechnics in Pipeline Engineering** will give detailed information about well-approved strategies for a failure-free and economic planning, operation and maintenance of high-pressure pipeline systems.

These issues are therefore at the heart of the technical sessions that, with approximately 40 lectures, make up the core of the ptc. Furthermore it will be followed directly by a series of detailed workshops and seminars that will run until Friday, May 16th. The last two days special seminars on: Safety, Integrity and Reliability as an Integrated Pipeline Management System; In-Line Inspection of Transmission Pipelines as well as Geohazards and Geotechnics in Pipeline Engineering; will give detailed information about well-approved strategies for a failure-free and economic operation and maintenance of high-pressure oil and gas pipeline systems were transferred.
More information on this event can be found at www.pipeline-conference.com

Contact

You have general question about PTC or other EITEP events? Please feel free to contact us:

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The International Pipeline Conference 2014

In September 2014, members of the pipeline industry from around the world will gather in Calgary for the 10th International Pipeline Conference (IPC 2014). Organized by volunteers representing international energy corporations, energy and pipeline associations and regulatory agencies, the IPC has become internationally renowned as the world's premier pipeline conference. This is a not-for-profit conference and proceeds continue to support educational initiatives and research in the pipeline industry.

The conference will begin on Monday, September 29, with tutorial offerings in key areas of interest. Technical Track sessions will begin the morning of Tuesday, September 30, and run through to Friday, October 3.

The International Pipeline Conference is designed to inform, enlighten and motivate, therefore we encourage you to actively participate in IPC 2014–five days of exceptional value, which you won't want to miss!

Calgary, Alberta, Canada - Sept. 29 - 03. Oct.

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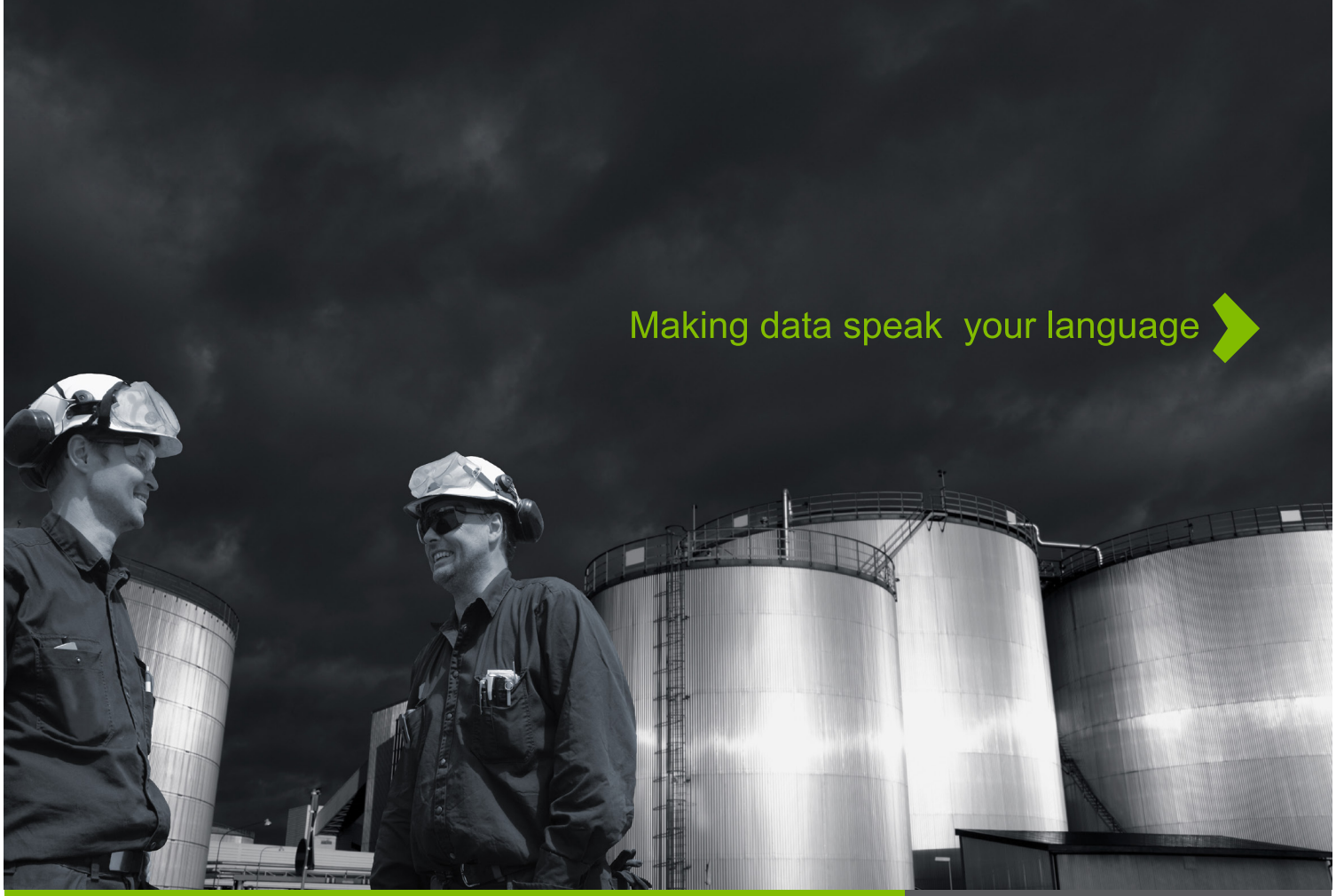

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