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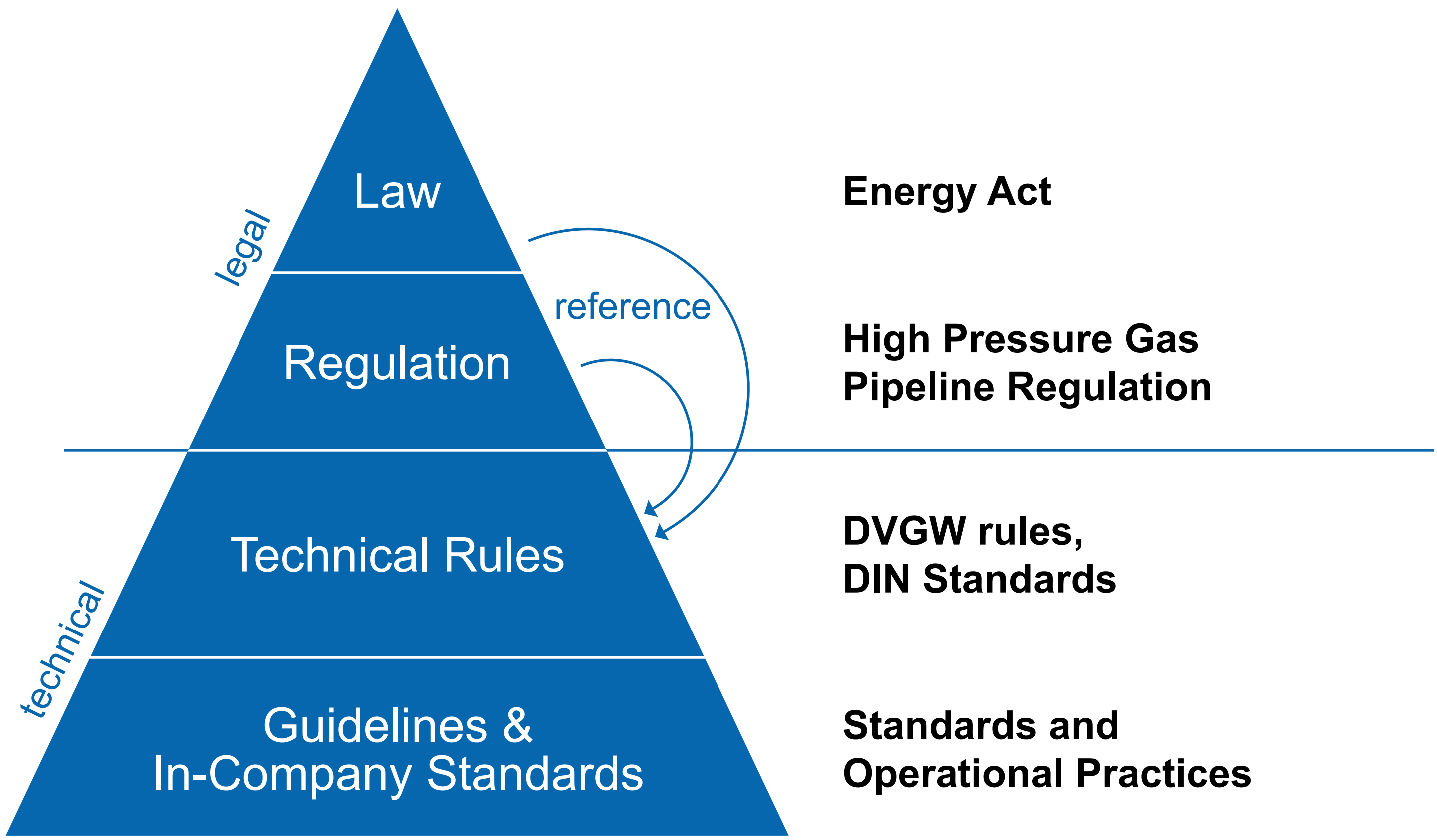

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Pipeline Safety in Germany A Success Story


Prof. Dr. Gerald Linke
CEO DVGW

Pipelines are the lifeline of our society and our economy, thus they deserve our attention in order to work safely and reliably. Pipelines transport gas, oil, water and other products over long distances, mostly over thousands of kilometers, from production facilities to the user. On their way, pipelines traverse mountains, cross lakes and pass densely populated areas.

Damages to pipelines threaten lives, can cause high costs and inflict harm to the environment. At the same time, more and more pipelines are crossing developing and emerging countries that do not have up to date technical standards, and this poses high risk.


Dr. Klaus Ritter
President EITEP

International exchange of experience is therefore indispensable to transfer knowledge on how to apply the most reliable and safe technology. This is important for all steps along the value-chain of pipelines: planning, construction and operation. Especially in the case of gas and oil pipelines, mistakes can lead to catastrophic incidents with far-reaching consequences. Taking into account the fact that the pipeline network (high pressure) length totals about 4 million km, and is being extended by 25,000 km every year, we are obliged to exercise prudence and attention to safety.

The Pipeline Technology Conference (ptc) and its publication the Pipeline Technology Journal (ptj) are instruments for fostering an exchange of experience and best practice. During this, Europe's leading pipeline conference, latest technological developments are presented by scientists, operators, service providers and administrators.

Since the first ptc, more than 12 years ago, safety has been a core topic. Safety was also discussed prominently during the last ptc in May 2017. DVGW – the German Technical and Scientific Association for Gas and Water – has been asked to report in a special session about its technical set of rules, their implementation in the field and their positive impact on pipeline practice. The German gas supply system excels in its high level of technical safety, not least due to the constant advancement of technical standards in the course of the DVGW's work on the Set of Rules. The focus of this edition of the ptj is the statistical evaluation of damage incident and accident data, the holistic safety methodology of the DVGW and the further development of the Set of Rules, taking into consideration current case law and scientific investigations as well as enhancements of the Set of Rules review process.

The decrease in the number of incidents in the German gas supply network in the past 30 years by 90% is a remarkable result of Germany's safety process and leads - even though the pipeline network has increased considerably in length and has aged over the same period - to the current frequency of nearly 0.01 incidents per 1,000 km per year. Nevertheless, improvements have to be made in areas where incidents occur more frequently in order to systematically reduce incidents caused by technical or human error.

The technical papers of the DVGW safety session are provided in this special edition of ptj. Due to the international interest in the aforementioned technical session, we have decided to augment this edition with additional papers with related topics.

The Pipeline Technology Conference will continue to discuss latest safety-related technological developments. The Pipeline Technology Journal will keep you informed.

Dr. Klaus Ritter
President EITEP
Euro Institute for Information and Technology Transfer in Environmental Protection

Prof. Dr. Gerald Linke
CEO DVGW
German Technical and Scientific Association for Gas and Water

The first publication of this special issue has met with a positive response worldwide. In Germany, the issue has occasionally been used for hearings in licensing procedures. This has prompted us to update and reprint the issue in English and German language.

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NOVEMBER 2018 / ISSUE 5

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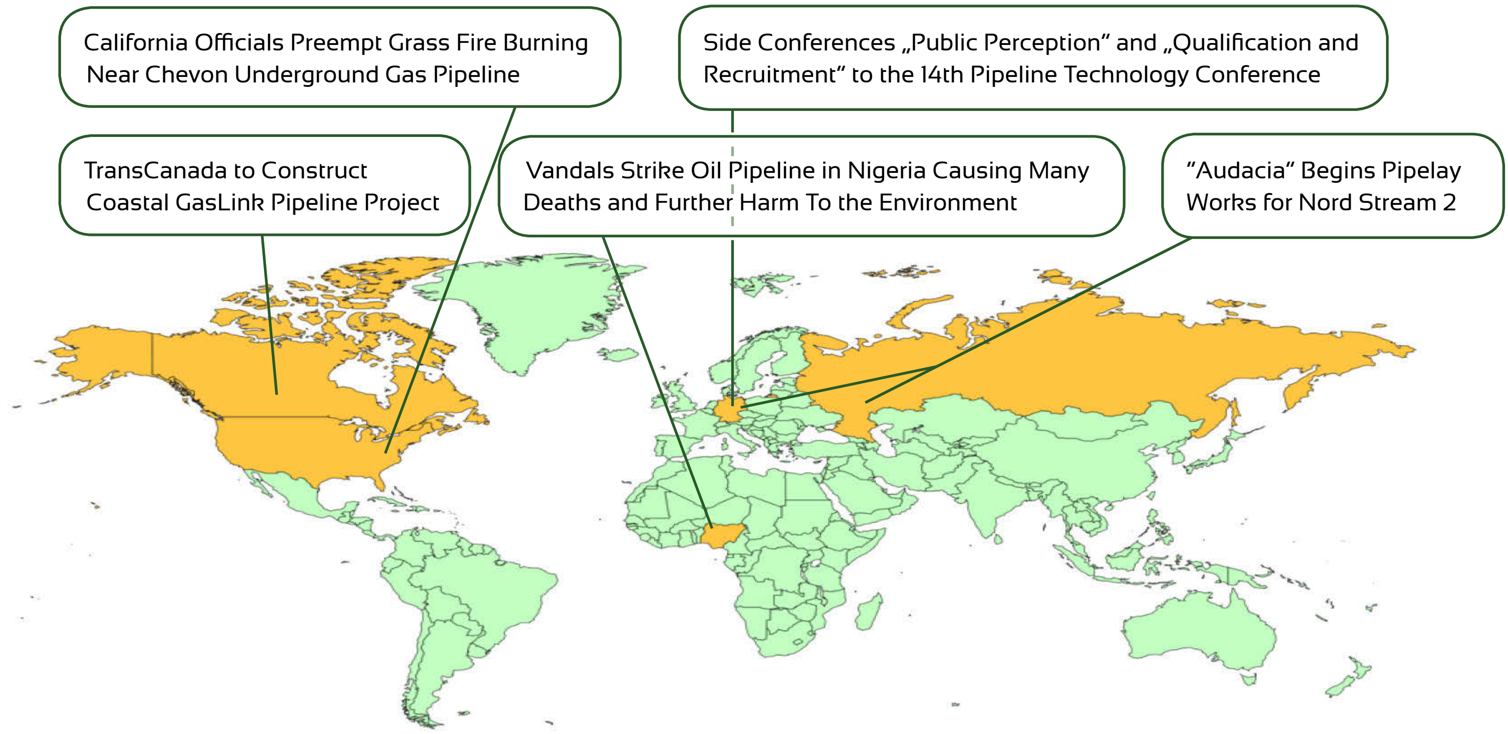

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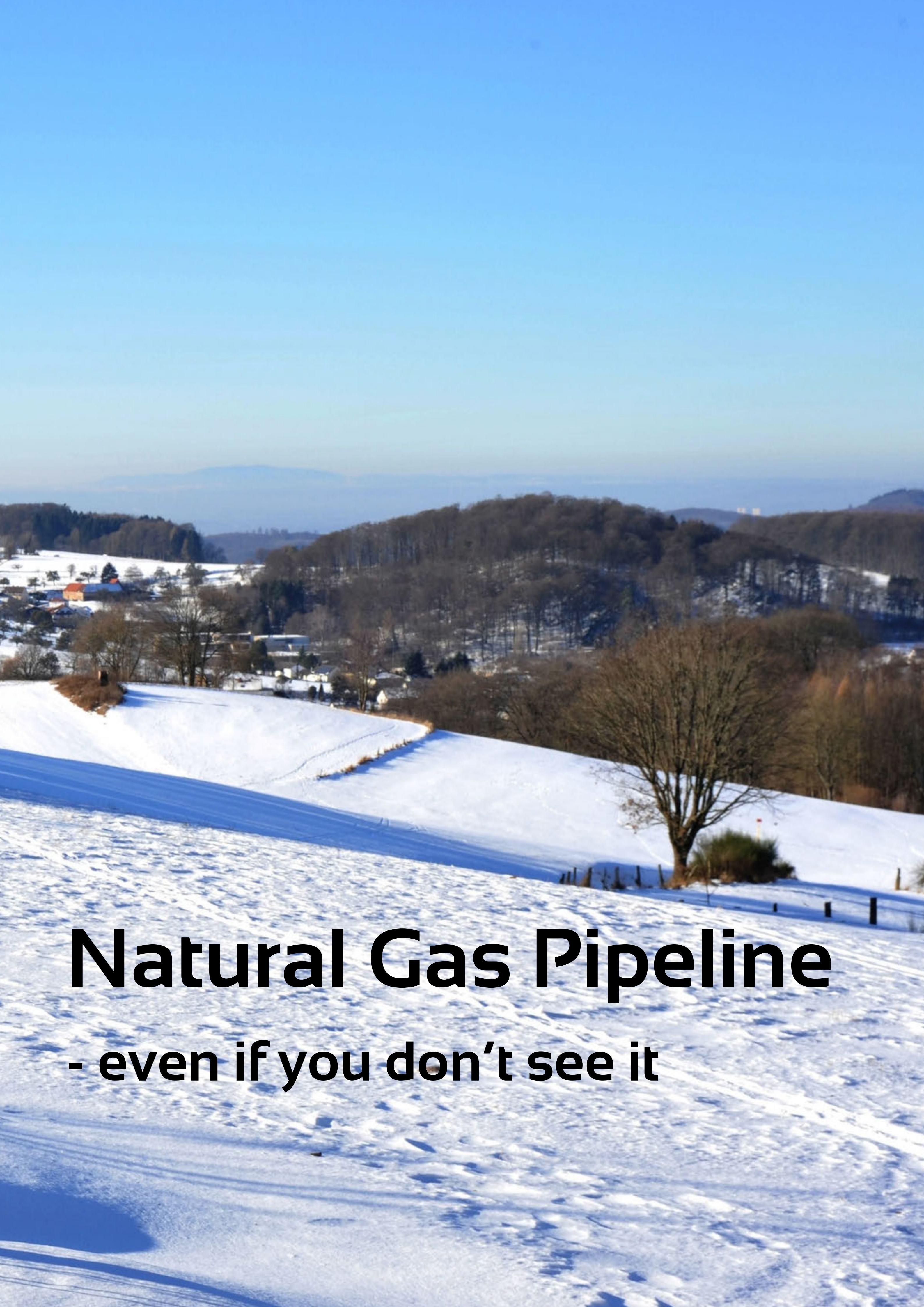


Natural Gas Pipeline

- even if you don’t see it

ENSURING THE TECHNICAL SAFETY OF GAS INFRASTRUCTURES IN GERMANY

Alfred Klees, Anika Groos > DVGW – German Technical and Scientific Association for Gas and Water

ABSTRACT

An extensive gas infrastructure system crisscrossing Germany ensures the high reliability of supply of heat and electricity to the civilian population, of process heat/ heat energy and natural gas as a raw material for organic chemistry to the industry, of highly efficient primary energies to power plants, and of alternative environmentally friendly fuels (CNG/LNG) to the transport industry.
The German gas supply system excels in its high level of technical safety, which is not least due to the constant advancement of technical standards in the course of the DVGW's work on the Set of Rules. The focus of this article is on the statistical evaluation of damage incident and accident data, the holistic safety concept of the DVGW, and on the further development of the Set of Rules, taking into consideration current case law and scientific investigations as well as an adjustment of the DVGW codification processes. It additionally discusses aspects that will affect the gas infrastructure in the context of the energy turnaround. This paper is the first of a series of technical articles that deal with the safety-related challenges facing the gas infrastructure.

The German gas grid currently consists of 550,000 km worth of closely intermeshed pipelines. Gas transmission lines cover nearly all of Germany (Figure 1). The structure shown in the figure has been built and expanded over the last two to three decades using cutting-edge technologies and materials.

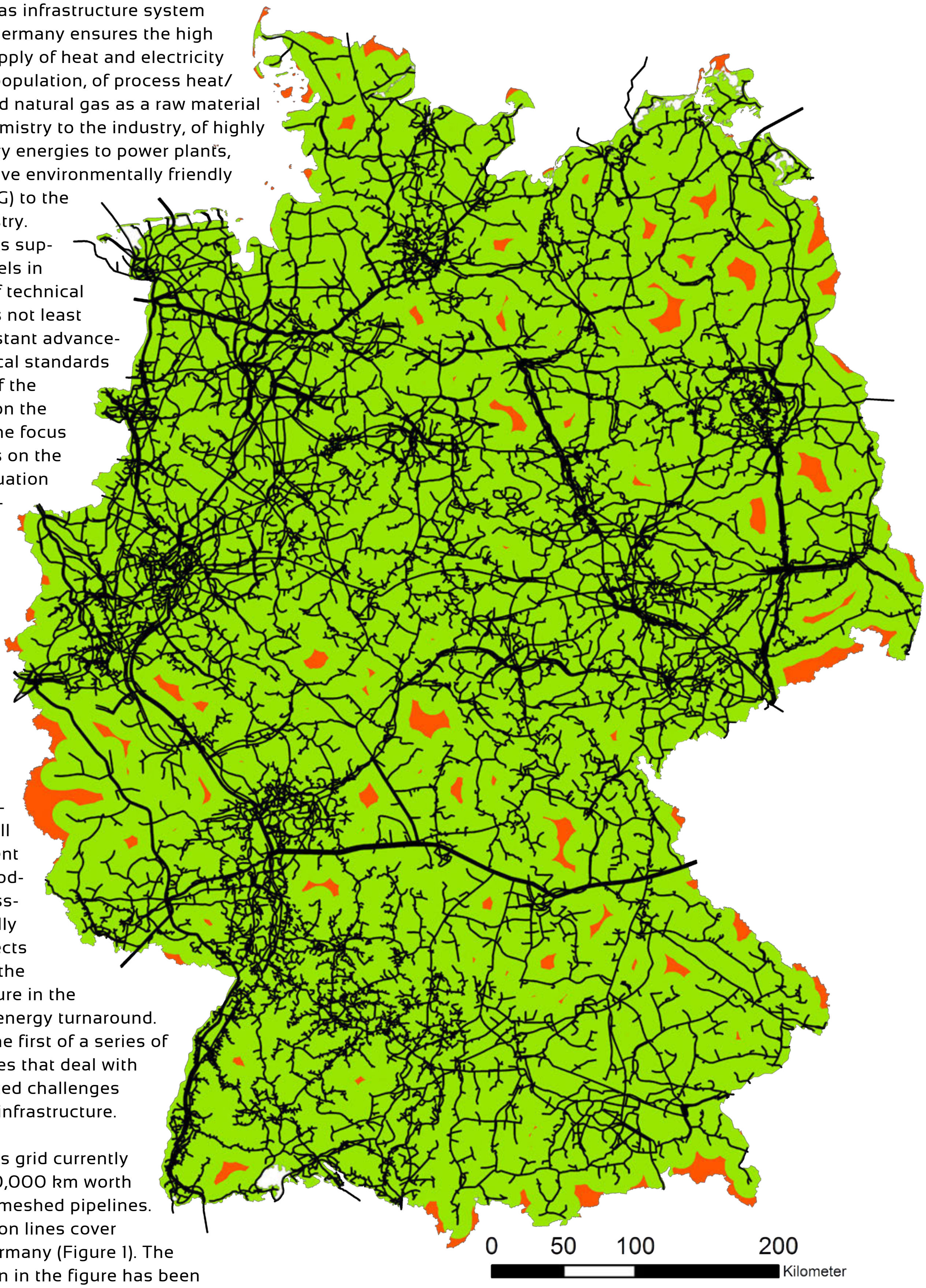


Figure 1: Germany's comprehensive gas infrastructure, this figure showing pressure classes > 4 bar
Source: GeoBasic-DE/BGK 2012/DBI

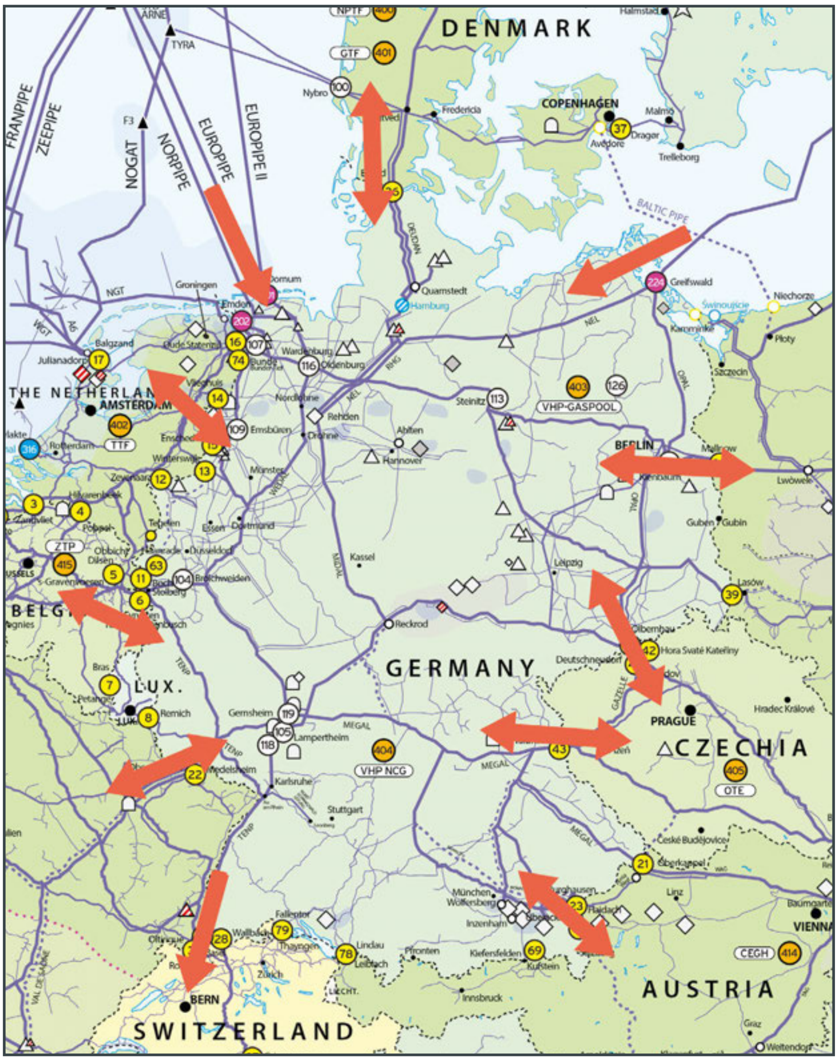


Figure 2: Its central geopolitical location makes Germany a gas import and export hub
Source: ENTSOG

ENERGY SUPPLY FOR GERMANY AS AN INDUSTRIAL LOCATION

Various energy carriers cover Germany's annual primary energy demand of currently about 3,644TWh (Figure 3), with 21 per cent of the primary energy coming from natural gas. Today 13 per cent of the energy demand is already covered by renewable energies; the intention is to substitute the remaining 87 per cent of fossil energies in the long run.

National energy policy is aimed at considerably reducing the primary energy demand across all sectors by 2040 by way of potential energy savings and/or efficiency increases.

Direct electricity generation from sun and wind does not produce waste heat, of which power plants such as e.g. coal-fired powered plants produce an amount greater than the generated electrical power. Assuming energy savings of approximately 3 per cent per year will still keep the use of primary energy at about 50 per cent.

Even assuming that energy demand could be reduced by as much as 3 per cent annually until 2040 as compared to the current trend, almost 50 per cent of today's energy consumption, i.e. almost 2,000TWh, will still need to be provided in a sustainable way [4].

Its geographical location makes Germany a hub for both gas imports and exports; as such, Germany plays a critical role in the European gas infrastructure network (Figure 2).

The German gas grid has a twofold task: first, to link import and export points and second, to link the main production and consumption points. This makes it one of the most complex technical structures in Europe.

Gas consumption is subject to strong fluctuations; it depends e.g. on the season, time of day, and economic cycles. Short-term supply and demand imbalances can be directly buffered in the transmission network.

Germany's geology provides for sufficient subsurface storage capacities so that even major fluctuations in consumption can be accommodated without difficulty [5].

Currently, the predominant renewable energy sources are wind power and PV. It is foreseeable that this trend will continue in the future as biomass, hydropower and geothermal are limited resources. National energy policy intends to increase the demand for "electrical power" in e.g. households and the industry, raising the impression that the world (of energy) is moving towards a fully integrated world of electricity, or all-electric-world, where energy is generated, transmitted, and consumed in the form of electricity.

> *"The German gas grid has a twofold task: first, to link import and export points and second, to link the main production and consumption points. This makes it one of the most complex technical structures in Europe.*
>
> Anika Groos

Alternative gas technologies however can increasingly be found on the agenda of discussions on energy policy.

Only about 2,454TWh worth of final energy out of 3,644 TWh worth of primary energy will eventually reach the consumer on account of conversion and transmission losses. The heat energy sector (space heating, hot water, and process heating) accounts for almost half of that (1,214TWH), while the electricity and transport sectors require considerably less energy (515TWh and 725TWh, respectively). Potential process heat energy savings are comparatively low. Moreover, electrically powered heat pumps can be used only up to a point because of the high temperatures required for their operation. Heat energy demand management however offers a huge energy-saving potential [4].

The more stringent requirements of the German Heat Insulation Ordinance have already helped to sustainably reduce the demand for heat energy (Figure 4).

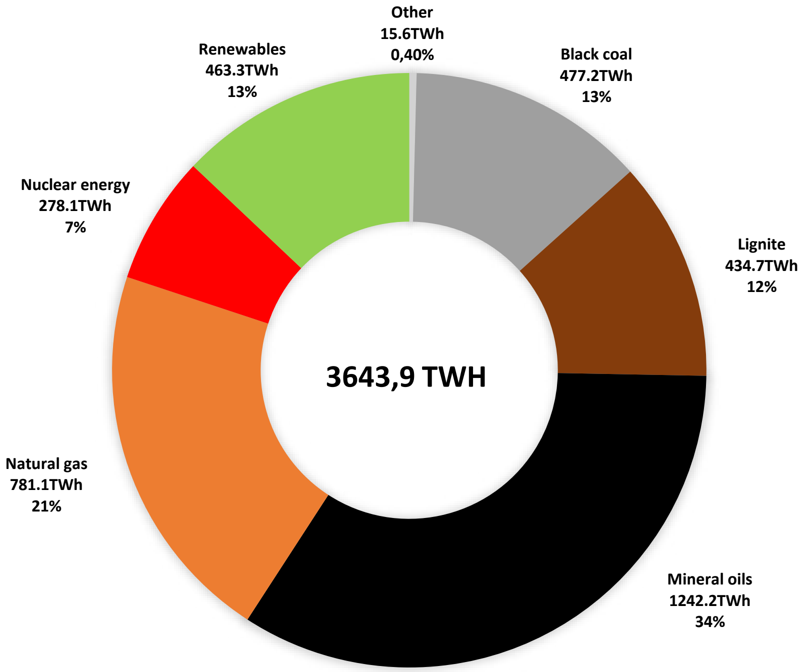


Figure 3: Primary energy consumption in Germany in 2015: 13 per cent of the energy is already obtained from renewable sources. Germany intends to substitute the remaining 87 per cent of energy from fossil sources in the long run
Source: AGEB 2016

Exploiting additional savings potentials offered by efficient appliance or insulation technologies could further reduce the current demand for primary energy. Highly efficient gas technologies, however, would make the most significant contribution towards drastically reducing emissions. Simply shifting from obsolete heating systems to gas condensing boilers could save 20 million tons of CO_2. This would go hand in hand with potential financial gains generated through energy savings. A further reduction of emissions can be achieved using CHP and "gas-plus technologies" such as gas-powered heat pumps [7].

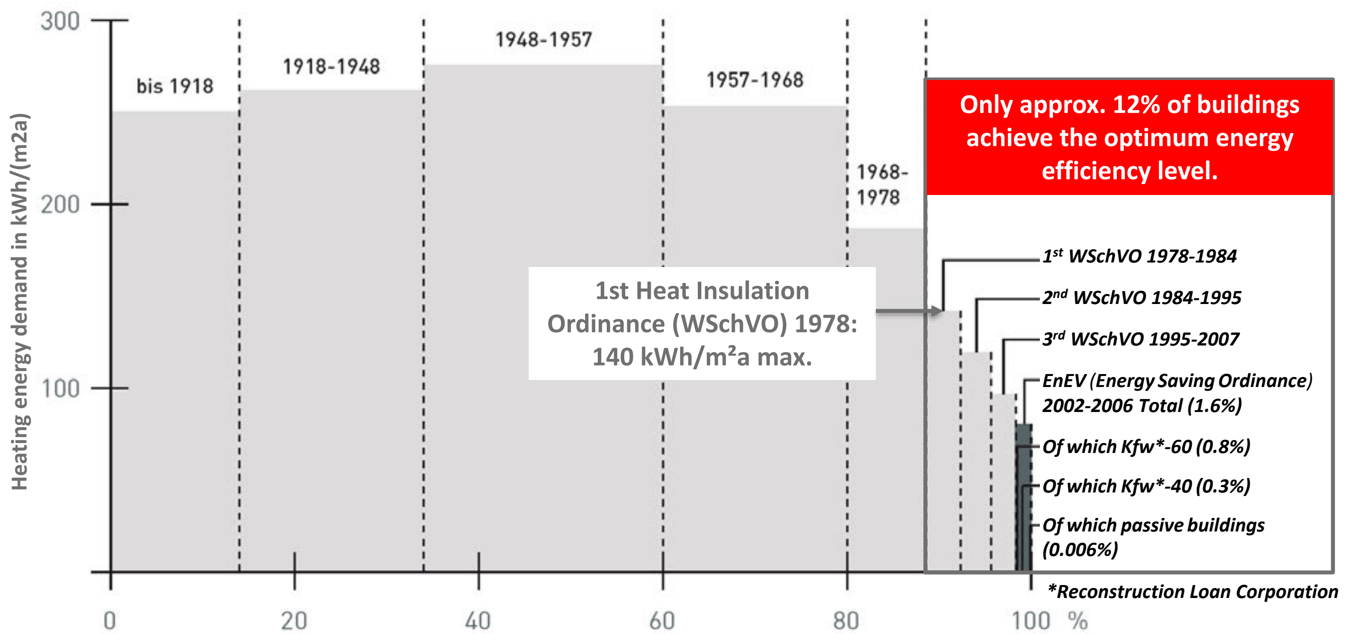


Figure 4: Heat energy demand of buildings. The energy turnaround in the heat market happens to the existing infrastructure

"By advancing the comprehensive safety concept that was developed in the early 1990's, the DVGW has set a milestone in the evaluation and reduction of damage and incidents in the gas supply sector by 90 Percent within the last 30 years...

Alfred Klees

HOW SAFE IS GERMANY'S GAS INFRASTRUCTURE?

In the light of continuing national and pan-European gas market regulations, current structural changes in the business environment and the fundamental reorganisation of the energy supply systems in Germany and Europe, it is the primary aim of the national economic and business policy to maintain a high standard of technical safety of the gas supply systems. By advancing the comprehensive safety concept that was developed in the early 1990s, the DVGW has set a milestone in the evaluation and reduction of damage and accidents in the gas supply sector. The statistical/stochastic analysis of incidence data collected from the damage and accident statistics of the DVGW has served as a basis for the elaboration of the cause-oriented catalogue of measures. It has helped develop and introduce tangible technology and process improvements as well as additional training and information measures for each cause-relevant target group, ensuring a sustainable high level of safety in the German gas supply industry. Figure 5 documents the resulting considerable reduction of the specific incident rate in the German gas grid [3].

The measures derived from the incident analyses have been gradually integrated into the state-of-the-art technologies codified in the DVGW Set of Rules; they guarantee a comparatively high standard of safety, with the focus here on gas pipelines. External mechanical interferences account for the lion's share of incidents, followed by corrosion damage. Defective material and incorrect work, e.g. tapping, assembly and construction defects, rank third.

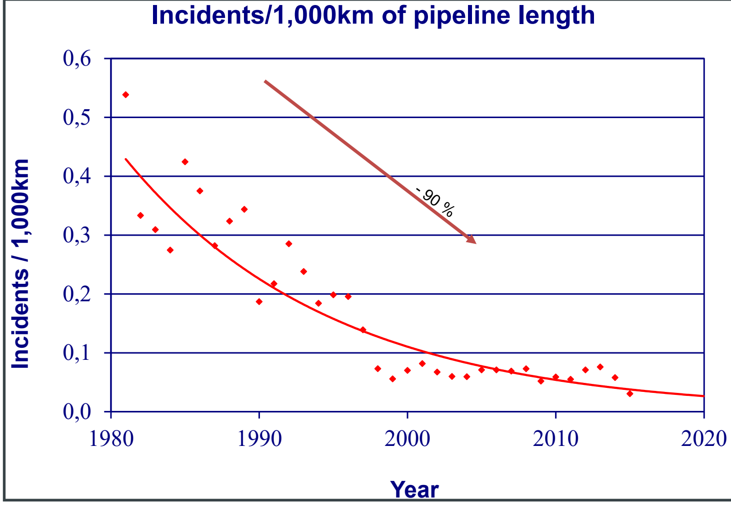
THE HOLISTIC DVWG SAFETY CONCEPT

As the DVGW's holistic safety concept is focused on suitable measures that can be implemented in all corresponding technical areas (Figure 7), it is not confined to the work on the Set of Rules.

The qualification and certification of products, individuals, service providers and management systems as well as of companies consequently play an important role.

The following quality requirements, among others, have been defined to reflect the high standards of the Set of Rules:

- Gas supply and gas application technologies are governed by stringent legal regulations such as the German Energy Industry Law (EnWG), the German High Pressure Gas Pipeline Ordinance (GasHDrLtgV), the German Low Pressure Connection Ordinance (NDAV), and the German Model Building Regulations (MBO), in which observation of and compliance with the DVGW Set of Rules are anchored as generally recognised codes of practice and/or state-of-the-art technology.
- The products used in gas engineering, service-providing com-panies, and the specialists/experts who are responsible for the technical acceptance tests are examined and certified on the basis of the DVGW Set of Rules.
- Only companies/individuals who have proved their expert qualifications are allowed to carry out construction, modification or maintenance work on gas pipelines and gas facilities.
- In addition, and for the purpose of monitoring the compliance with the technical safety requirements stipulated by law and the Technical Rules, the DVGW provides the industry with guidance on practice-oriented Technical Safety Management (DVGW TSM).



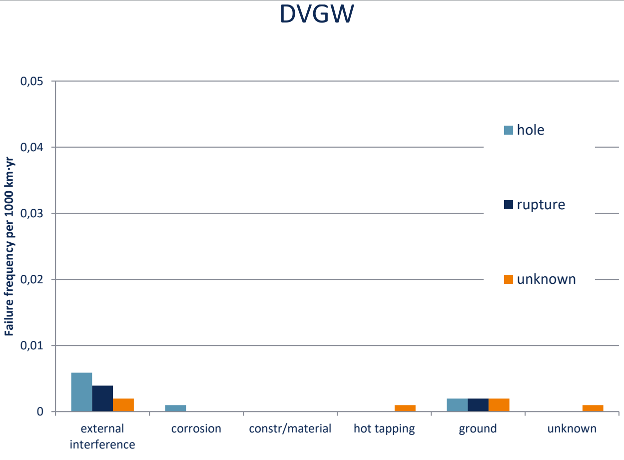


Figure 5: History of gas pipeline incidents in Germany. Since 1980 the incident rate has dropped by 90%

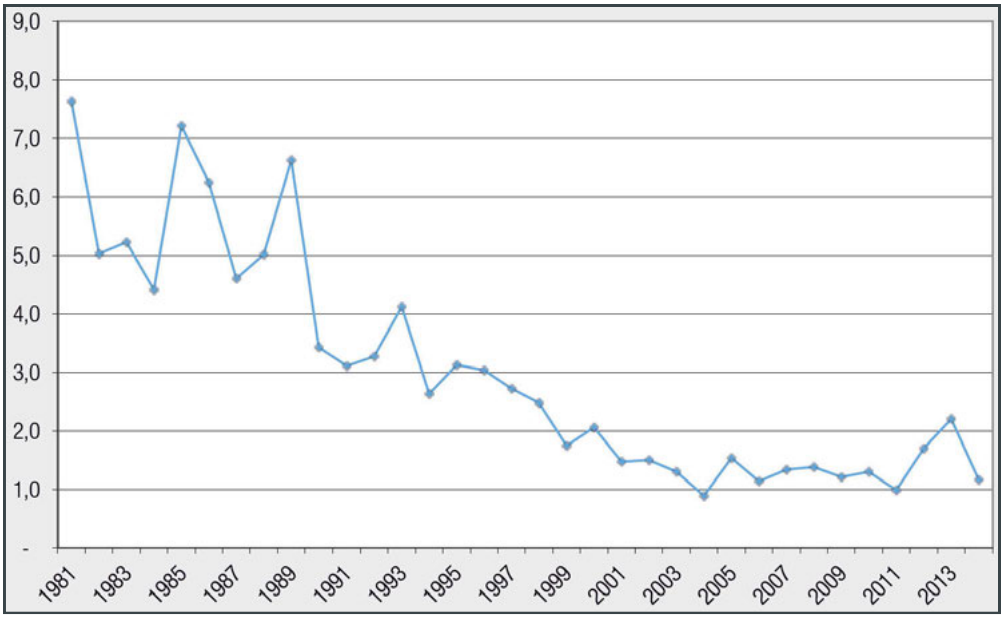


Figure 6: Decline of incidents in customer facilities since 1981 Source: BDEW, DVGW (Incidents in customer facilities per 1m natural-gas heated residential units)

This is why for two decades the DVGW Set of Rules has backed two methods to ensure safety: Protecting the lines against third party interference and equipping them with sophisticated technical safety features.

The preference of safety distances over technical safety solutions is not congruent with the historic experience of the DVGW Set of Rules because frequently identical or even higher technical safety can be achieved by employing technological solutions other than distances. In this context, the following primary safety measures have proved especially successful:

- Pipeline design with a high safety factor (1.6);
- Installation of shut-off valves;
- 100 per cent check of construction site weld seams;
- Hydrostatic tightness and strength tests of the pipeline sections;
- Marking of the pipeline route with signposts;
- Passive and active corrosion protection;
- Checking of the protective sleeve by so-called intensive measurements;
- Short inspection intervals for surveillance on foot and by air;
- Inspection by modern pigging technologies;
- Tightness tests to determine the smallest of leakages.

The following additional safety measures, among others, are also applied:

- Higher depth of cover;
- Setting up of pipeline route warning tapes;
- Hydrostatic stress tests.

Even comparable Sets of Rules such as, for instance, the German Technical Rules on Long-distance Pipelines (TRFL) do not contain any information on distances from built-up areas, as evidenced by an enquiry from the state parliament of Baden-Württemberg (Landtag) to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU):

> *... The statistical / stochastic analysis of incidence data collected from the damage and accidents statistics of the DVGW has served as a basis for the elaboration of cause-oriented catalogue of measures.*
>
> Alfred Klees

OBSERVATION OF CASE LAW AND SCIENTIFIC RESEARCH

Ongoing technological progress keeps the Set of Rules of the DVGW constantly evolving, always with the aim of reflecting state-of-the-art technology. These evaluations also take into account case law developments.

For example, the expedited ruling of the Higher Administrative Court (OVG) of Lower Saxony in Lüneburg on 29 June 2011 led to an immediate construction freeze on some sections of the Northern European Natural Gas Pipeline.

The OVG simultaneously assessed the safety of gas pipelines - disregarding the usual risk assessment procedures employed for technical facilities - and defined more stringent safety measures in respect of such lines, employing a previously unknown safety technology - the distance from residential buildings. In "DVGW energie | wasser-praxis" 1/2012 the DVGW took a stance by making the following core statements:

- Supply lines shall be carefully guided up to residential and industrial areas.
- Protecting the lines is the most effective protection of the public at large.
- No further safety distances are generally required for lines running through a protection strip.
- Not only distances but also any other technical measures have to be taken into consideration.
- The analysis of the Federal Institute for Materials Research and Testing (BAM) [1] only looks at certain aspects and relates to worldwide incidents on pipeline that were partially built and operated according to obsolete standards.

(Landtag von Baden-Württemberg [Regional Parliament of the Federal State of Baden Württemberg]), Drs. 14/6687, p. 28): "In knowledge of the BAM research report the new TRFL will also not specify any minimum distances to be kept to built-up areas with residential buildings. The BMU communicated that the revised Technical Rules for Pipelines (TRFL) intentionally do without the definition of safety distances. It has to be decided on a case-by-case basis which specific action to take. Within the meaning of this definition, case-by-case refers to special situations as mentioned and described in TRFL no. 5.2.5. Since the individual measures listed under TFRL 5.2.5 are not exhaustive ("e.g."), an increase of the distance could be counted among these measures. This means that in a specific case it shall be tested whether one or more of the listed measures will/has to compensate for the concrete, higher potential risk. However, the proximity to residential buildings alone does not constitute such a special situation."

This goes to show that all in all, the TRFL defines 'state-of-the-art' differently from the expedited OVG ruling.

Moreover, it is noteworthy that the pipeline incidents evaluated by the BAM research report 285 partially date far back in the past. It is, therefore, extremely significant that most of the incidents that were evaluated are associated with lines built according to a now-obsolete state-of-the-art. Many other incidents occurred in non-European countries where other sets of rules apply.

Furthermore, the report focuses exclusively on damage impacts, completely ignoring the root causes of the incidents or the probability of damage occurrence. The determination of the severity of damage such as the blast radii mentioned in the research report or the calculation of risk arising from the operation of gas pipelines therefore are of very limited validity [6].

On 14 November 2011, the Administrative Court (VGH) of Mannheim [2] issued a formal decision in respect of the BAM research report, in which it refutes the contention that the research report would demand specific minimum distances. The decision moreover holds that the state-of-the-art can also be ensured without defining unambiguous minimum distances. Furthermore, the VGH Mannheim generally recommended not departing from the standards stipulated in the Set of Rules, unless in case of substantiated scientific and technological advances.

Although the DVGW's opinion - which was published in 2011 - on the expedited ruling of the OVG Lüneburg made clear that applying the DVGW Set of Rules ensured consonance with the state-of-the-art, the DVGW additionally evaluated the safety-related integrity of gas pipelines on a scientific level [6].

TECHNICAL REGULATION BASED ON SCIENTIFIC RESEARCH

The DVGW "Safety of Gas Pipelines" project group took part in the scientific investigations and summarised the findings for the concrete work on technical regulations by the DVGW expert panels. The following guidelines are now observed in the context of preparing technical regulations:

- The deterministic safety concept of the technical regulations will be maintained, however with the option of adding probabilistic statements.
- The Set of Rules shall protect man and nature; safety measures applied in the field today shall be integrated into the Set of Rules.
- The documents of the Set of Rules shall reflect the state-of-the-art and consider all sources of knowledge.
- Incidents and findings from damage statistics (DVGW damage and accident statistics (G410), European Gas pipeline Incident data Group (EGIG), etc.) shall be taken into account especially when drafting regulations.
- The worst-case damage scenario, e.g. total rupture, shall be taken into account.
- Mandatory technical safety measures shall be specified; their efficiency, availability and accuracy shall be evaluated and harmonised at regular intervals with new sources of knowledge.
- Risk potentials shall be taken into account regarding the type, number, and efficiency of the protective measures.

At the same time, the DVGW has developed a methodological approach with the intention being to logically represent the implementation of the above-mentioned guidelines; this procedure specifies binding goals, to be confirmed by the members, for each project group commissioned with elaborating a document that forms part of the Set of Rules.

The guidelines have also been incorporated into the current version of the Rules of Procedure GW 100 of February 2016 and thus constitute a binding guidance for the work of the DVGW committees with its main focus on taking into account new knowledge sources.

CONCRETISATION OF SCIENTIFIC FINDINGS AS STATE-OF-THE-ART

The DVGW Set of Rules feeds on the wealth of practical experience from companies as well as incident statistics analyses and other relevant sources of knowledge. Targeted scientific research completes the evaluation material for the codification of state-of-the-art technology.

Meanwhile, a large number of DVGW Sets of Rules has been adjusted (see information box) against the background of diverse scientific research as well as technological progress and the knowledge derived from it. Some of the fundamental changes are illustrated by way of example of DVGW Standards G 463 and G 495, as follows:

Crucial safety-relevant amendments in DVGW Standard G 463 "High Pressure Gas Steel Pipelines for a Design Pressure greater than 16 bar - Construction", July 2016:

- Specification in the scope of application that there is no upper limit on nominal diameters and design pressures;
- Increase of the pipeline depth of cover to at least 1.0 metres;
- Cathodic corrosion protection shall always include gas transmission lines;
- Gas transmission pipelines shall be piggable;
- Harmonised rate of use of 0.625;
- Stricter requirements for the marking of gas transmission pipelines in built-up areas.

Crucial safety-relevant amendments in the DVGW Standard G 495 "Gas Plants and Systems - Operation and Maintenance", November 2016:

- Consideration of the latest health and safety regulations in respect of the operation and testing of gas plants;
- Integration of requirements on the monitoring of heat transfer cycles in respect of corrosion;
- Further development of the requirements for the condition-based maintenance (CBM) of gas plants and extension of CBM to domestic pressure regulators based on the findings of the relevant research projects;
- Increased consideration of design features such as redundant safety features of devices and rails to increase their intrinsic safety and reduce the likelihood of failure;
- Inclusion of the requirements on the operation of mobile gas measurement and pressure reduction stations.

What is more, a large number of new papers published in 2015 and 2016 have been prepared applying the above-mentioned enhanced safety-relevant guidelines. The revised Sets of Rules are based on the scientific findings from various analyses, among other things, and, therefore, constitute key elements in continuing the scheduled publication series on ensuring technically safe gas supply to and in Germany.

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INTEGRATED SAFETY CONCEPT OF DVGW IN TERMS OF STATISTICAL VERIFICATION OF INCIDENTS

Frank Dietzsch > DVGW – German Technical and Scientific Association for Gas and Water

ABSTRACT

The guarantee of a high safety standard of the gas infrastructure must be the highest goal of economic and operational action within the framework of proceeding national and European regulation and the organisational changes interrelated in the companies [1].

At the beginning of the 1990th DVGW, the German Association for Gas and Water, developed an integrated safety concept and thereby set a milestone for the evaluation and reduction of incidents and accidents in the German gas infrastructure. The basis for the development of the cause-oriented tool box was the statistical analysis of data coming from the incidents and accident statistics of DVGW. By means of this precise technical and process improvements as well as further trainings and awareness campaigns could be developed and introduced which have led to a high safety level within the German gas infrastructure.

In 2011 the damage and accident statistics were made state-of-the-art according to Section 49 of the Energy Industry Act by the publication of a code of engineering practice (cf. DVGW G 410 "Bestands- und Ereignisdatenerfassung Gas" - Registration of Asset Inventory and Incident Data of Gas Infrastructures). This makes the application of the code mandatory for all gas infrastructure operators. The data are published annually on an internet portal or interface (cf. GaWaS.strukturdatenerfassung.de).

Initial results of the data evaluation for the years 2011 to 2014 are presented in this article.

> *"Precise technical and process improvements as well as further trainings and awareness campaigns led to a high safety level within the German gas infrastructure.*
>
> *Frank Dietzsch*

DEVELOPMENT OF GAS DAMAGE AND ACCIDENT STATISTICS

In 1978 Germany's Ministry of Research and Technology commissioned a study into "Safety in municipal gas supply companies for households and businesses" [2]. The aim of the study was to develop proposals and concepts for improving the safety of public gas supply systems, and attempts were made in the analysis to establish a correlation between damage and accident events on the one hand and the occurrence of (unwanted) gas releases on the other. At that time the analysts only had access to information from heterogeneous data collections, e.g. derived from pipeline grid statistics from local supply companies or from quarterly reports in the Health Service series published by the Federal Statistical Office. An overview for the whole territory of the Federal Republic of Germany was just not available.

Then in 1979 the "Safety and Fire-Fighting" group of experts of the Ministry of Research and Technology recommended producing damage and accident statistics for the public gas supply system. This recommendation was taken up by the DVGW which invited its members to exercise their personal responsibility by taking part in a data survey to commence on 1 January 1981 [3]. This quasi mandatory requirement to participate in DVGW statistics continued right up until 2011.

The current energy-law framework and the fact that the assets held by supply companies have been continually expanding with the addition of new types of plant such as biogas entry and/or conditioning systems or natural gas service stations for example must receive reasonable consideration when it comes to the future formulation of technical rules and regulations. This is the background against which the DVGW "Registration of Asset Inventory and Incident Data of Gas Infrastructures" has been restructured. In 2011 the DVGW took up a recommendation by the joint national and regional "Gas Industry" committee to transform the damage and accident statistics which had been collected since 1980 into a code of engineering practice [1].

In the meantime, since 2012 the registration of asset inventory and incident data of gas infrastructures has been a firm part of DVGW's technical rules. The data registration criteria described in the technical rule G 410 comprise the following reports (cf. figure 1):

- inventory data for gas pipelines, gas service lines and gas-related facilities,
- incident data for gas pipelines, gas service lines and gas-related facilities and
- customer installations of domestic and industrial gas usage, gas odour notifications,
- indications of interruptions of supply according to the Energy Industry Act.

	Pipeline network	Pipeline facilities	Consumer installation
Asset data	Details on specific length of pipelines (for gas service lines: additionally **amounts**)	Details related to **amounts**	------
Incident Data	Detailed Information	Detailed Information	Detailed Information
Gas odour notifications			
Indications of interruptions of supply			

Figure 1: Data scope according to DVGW G 410 (A)

All operators of gas-technical energy systems as defined by the Energy Industry Act must now submit their inventory data to the DVGW each year. As in the past, incident data must be reported immediately after the occurrence of an incident to the DVGW, to the energy supervisor in the Federal 'Land' concerned and to the Federal Ministry for Economic Affairs and Energy. This requirement does not apply to incidents only involving a release of gas only from pipelines or service connections with no other consequences – these must be reported annually by a due date. The DVGW treats data supplied by operators as confidential (cf. Figure 2).

The DVGW publishes standardized reports at reasonable intervals. These reports contain only aggregated data from which no inferences can be drawn about individual system operators but which do reflect the general developments taking place in the German gas industry. The reports make statements about changes in pipeline and plant inventory and about trends in safety performance indicators. The first report was published in 2016 [4].

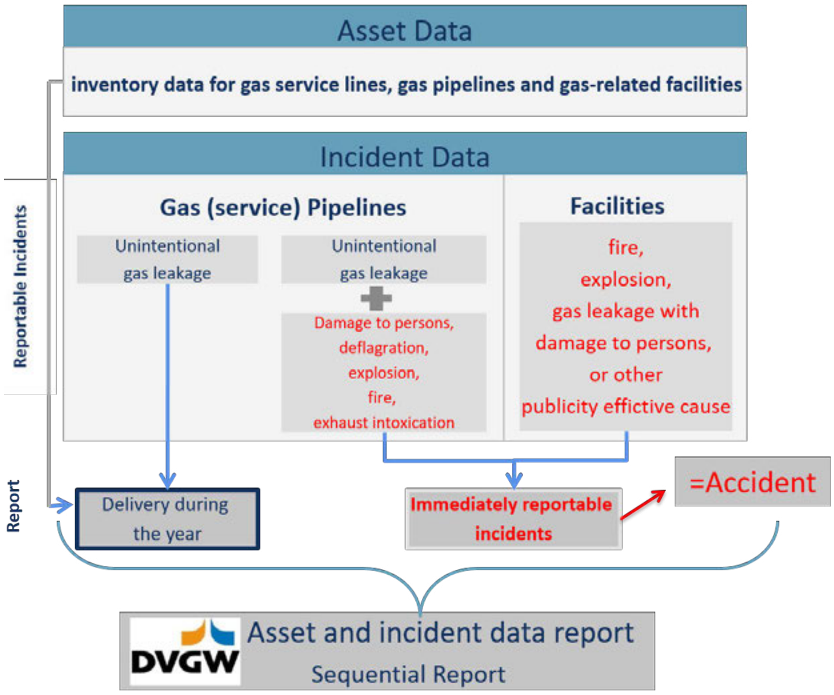

Figure 2: Data collection and reporting according to DVGW G 410 (A)

RESULTS OF DATA ANALYSIS FROM 2011 TO 2014

Analysis of pipeline and service connection inventory

Data is collected broken down by domestic service connections, pipelines operated by distribution system operators (DSOs) and pipelines operated by transmission system operators (TSOs). For pipelines an additional distinction is made between pressures of MOP ≤ 16 bar and MOP > 16 bar.

For the first analysis, the released data for the data collection years 2011 to 2014 were averaged. A comparison of the sum of the pipeline lengths from the structural data collected by the DVGW (average for 2011 to 2014: 318,537 km) with the sum of the pipeline lengths of the 2014 network structural data of the Federal Network Agency BNetzA [5] (518,683 km) indicates a coverage of 66 %. For MOP > 1 bar pipelines the coverage is no less than 93 %.

Service connections are differentiated by their pressure (MOP), diameter and material. All in all, 7,987,656 service connections with a total length of 131,946 km are covered. Figure 1 shows the percentage breakdown by these distinguishing criteria. 72 % of all connections use PE as their material, reflecting the rapid system expansion in the last decades and a high rate of renewal of service connections in the gas sector.

Approximately 300,000 km of DSO pipelines have been surveyed. Here again the proportion of plastic now predominates, with 54 % of pipelines made from PE and 37 % from steel. With just 0.8 per thousand, grey cast iron is all but irrelevant in the overall pipeline inventory. If we look at the age structure of pipelines we find that 47 % were constructed or refurbished between 1990 and 2014. This bears witness to a young and modern gas grid, something which the material structure already indicated with PE and PE coating. The average age of the grid is around 30 years.

DVGW statistics show that transmission system operators own a reported pipeline inventory with a total length of 21,024 km. As well as MOP and year of construction, in their returns TSOs also differentiated pipelines in the MOP > 16 bar category by diameter, material, wall thickness and coating. In terms of possible comparability therefore, the DVGW has followed and applied the

> *All Operators of gas-technical energy systems must submit their inventory data to the DVGW each years. As in the past, incident data must be reported immediately after the occurrence of an incident to the DVGW, to the energy supervisor in the federal state and to the Federal Ministry for Economic Affairs and Energy.*
>
> Frank Dietzsch

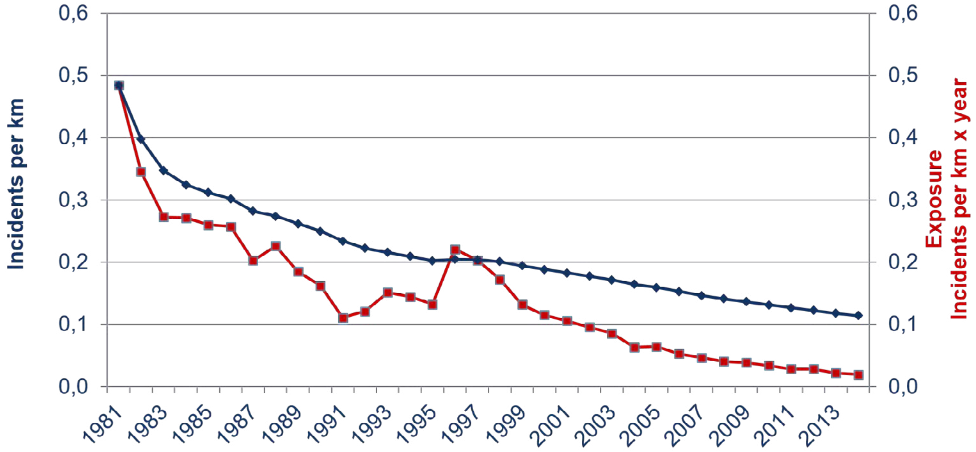

Figure 3: Trend in incidents from 1981 to 2014 on all gas pipelines

The total number of incidents has been standardized to the corresponding total operational experience so as to ensure comparability with the European EGIG database [6]. The term 'operational experience' here refers to the cumulative total pipeline length which increases year on year by the current total pipeline length.

Incidents on gas pipelines during the period 1991 to 2014 are shown in Figure 4 by pipe material. The peak in grey cast iron already mentioned is clearly visible between the years 1995 and 2000. In more recent years there has been a clear tendency for material-specific damage rates to fall within the range of 0.1 incidents per kilometre (except for ductile cast iron).

data collection criteria of the European EGIG statistics kept since 1970 (European Gas pipeline Incident data Group, cf. www.egig.eu). Similarly to the DSOs, the average age of these pipelines is something over 35 years. In statistical terms, the most frequent material used in TSO pipelines is StE 480 (40%), with a wall thickness of over 5 and up to 10 mm (47.1%) and with equal proportions of PE or tar/bitumen coating (approx. 33% each).

ANALYSES OF PIPELINE AND SERVICE CONNECTION INCIDENTS

During the period from 1981 to 2010, leaks and damage incidents – divided into six categories of cause – were reported within DVGW damage and accident statistics. Starting from the 2011 reporting year, the definitions given in DVGW code of practice G 410 apply, with only incidents involving an unintended gas release being reported.

Figure 3 shows that the incident rate on all gas pipelines has decreased by a factor of ten in the last two decades. The temporary rise in the incident rate in the late 1990's was put down to an increased rupture hazard with grey cast iron (see also Figure 4), a trend that was countered with appropriate measures (a nationwide programme of grey cast iron rehabilitation). From the year 2000 onwards the incident curve falls more uniformly compared with previous years, and this should be down to the improved quality and quantity of the collected data.

An analysis of the data also shows that mechanical third-party intervention (e.g. damage caused by excavators) is the main cause of incidents involving service connections and supply lines made of plastic. With service connections made of metal materials, a high percentage of corrosion is found to have been the cause of the incident. Compared with all other materials the damage rate of 0.8 incidents per kilometre for service connections made from ductile cast iron (GGG, cast iron with globolitic graphite) is the highest.

The metal supply lines show a high proportion of corrosion as the cause of incidents, with the percentage

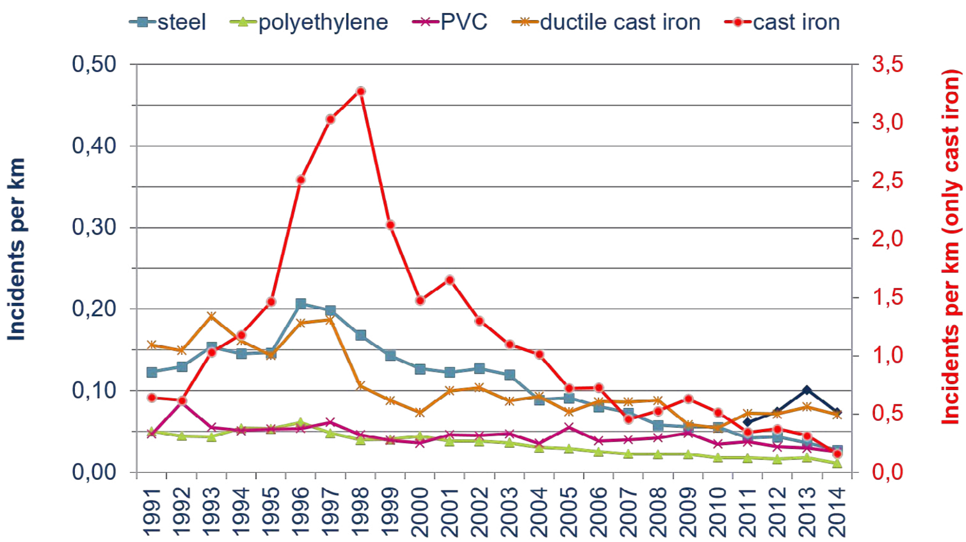

Figure 4: Trend in incidents between 1991 and 2014 on all gas pipelines by material groups

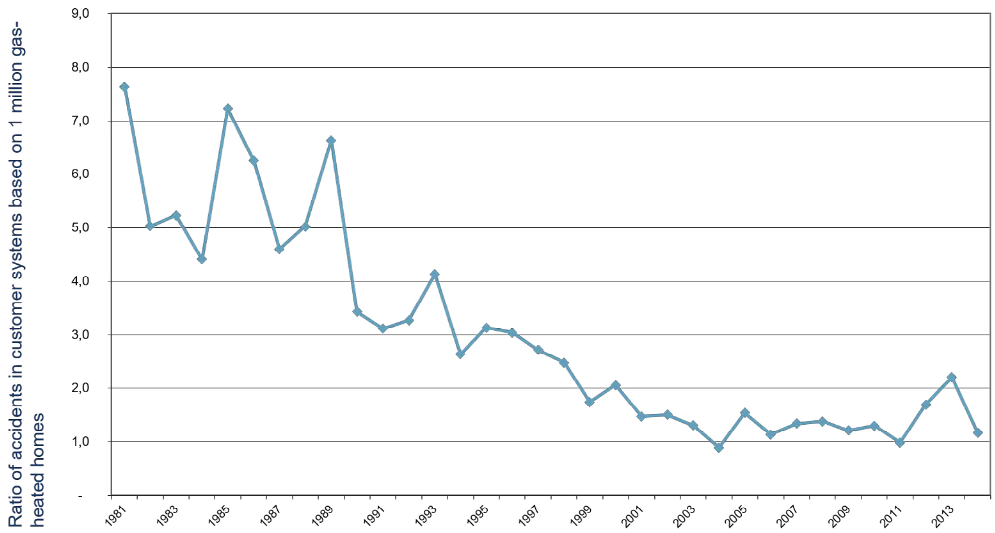

Figure 6: Ratio of accidents in customer systems based on one million gas-heated homes

for bituminised steel lines being around 80 %. The proportion is significantly less with younger steel pipelines with a PE coating. On average the incident rates for steel pipelines with a bituminised coating and cathodic protection (CP) are about one sixth of those with a bituminised coating but no CP. Compared with plastic-sheathed steel pipelines the positive influence of CP can be clearly seen here, not least a consequence of the greater age of the lines. Among the supply pipelines too, grey cast iron (untreated) returns the highest incident rate (0.363 incidents per kilometre).

For TSO pipelines the number of incidents is a mere 2.2 per thousand of the number reported for DSO supply lines, and so the statistical analysis is limited to a consideration of the cause of the incident. Corrosion has the biggest share of incident causes, followed in second place by third-party mechanical intervention. Material defects and incorrect working (e.g. drilling, assembly and construction defects) follow together in third place.

An analysis of the distribution of all incidents with a recorded leak size indicated for the period under review that approx. 56 % of incidents are very small in size (e.g. corrosion leaks), whereas only 1.4 % of incidents involved a very significant release of gas. Approx. 30 % of all incident reports were unable to give any qualified leakage size (meaning an unknown size of leak).

Immediately reportable incidents with operators' own systems

Trends in immediately reportable incidents involving systems owned by TSOs and DSOs since 1981 are shown in Figure 5. The rate of immediately reportable incidents shows a continuous reduction, especially for the number of incidents based on operational experience in the past 20 years. In the period under review – 2011 to 2014 – third-party mechanical intervention was the main cause of all immediately reportable incidents, with 39 %, followed by third-party thermal intervention with 25 %.

Immediately reportable incidents with customers' systems

The ratio of immediately reportable incidents per annum to the number of gas-heated homes [7] for the period since 1981 is shown in Figure 6.

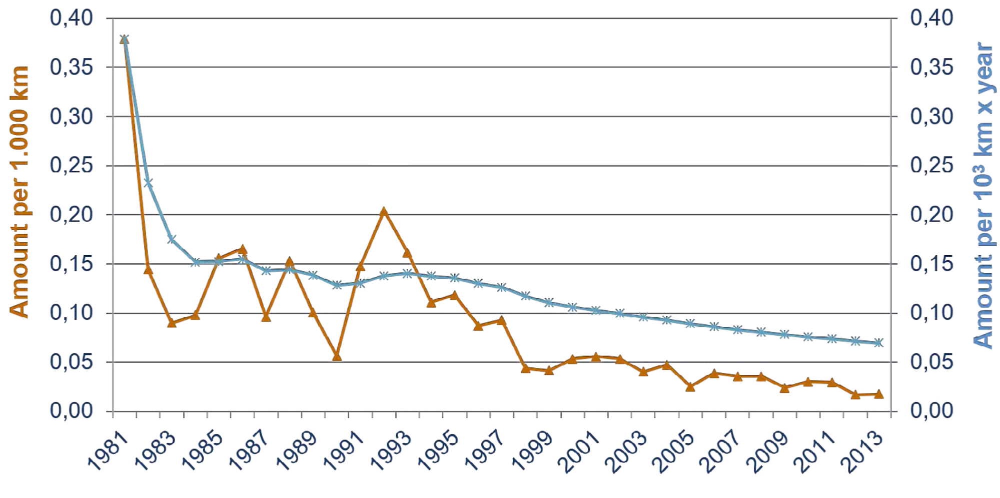

Figure 5: Trend in immediately reportable incidents since 1981

Just as with the immediately reportable incidents in system operators' own plants, the immediately reportable incidents in customer systems also reflect a continuous decrease. In the past 15 years overall there have been between 1 and 2 accidents per million gas-heated homes per annum.

In the period 2000 to 2014, the immediately reportable incidents broken down by causes are distributed

> *"In the period from 1981 until today the tendency of the absolute total incident rates has been decreasing by 90 Percent and is presently moving on a low historical level of 0.01 incidents per 1,000 km per year.*
>
> Frank Dietzsch

between component defects "technical defects", e.g. gas piping, gas appliances or waste gas systems (34 %), installation-related defects "installation errors" (10 %) and faults caused by customers such as "deliberate interference with the gas system" (28 %), "operator error/lack of maintenance" (14 %), "incorrect intervention in the gas system" (11 %) and "inadmissible changes in the set-up of gas appliances" (3 %). Defects caused by customers therefore account for 56 %.

SUMMARY AND CONCLUSIONS

In the period from 1981 until today the tendency of the absolute total incident rates has been decreasing and is presently moving on a low historical level. The normalised incident rates on gas pipelines (transport and distribution network) are also decreasing and have stagnated for at least ten years independent from the pressure range.

This can be interpreted as a steady improvement in quality and safety standards in the operation of gas pipelines according to the DVGW codes of practice.

The increased use of plastics as a material in pipeline construction by distribution system operators as well as the rehabilitation of pipelines made with grey cast iron is one reason for the general decline in incident rates. Incident analyses also indicate a significant reduction in corrosion incidents with steel pipelines that have cathodic protection (CP) as opposed to those with no active CP. We should emphasise the age-specific analysis of the incidents which shows that gas pipelines constructed prior to 1970 return an incident rate that is significantly higher than more recent construction years.

An analysis of all immediately reportable incidents shows the main cause as being mechanical intervention by third parties, followed by thermal third-party intervention. Thermal third-party intervention proves to be the main cause among domestic service connections while mechanical intervention by third parties is the predominant factor in high-pressure gas pipelines over 16 bar. It should be remembered here however that the level of incidents among transmission system operator pipelines with the greatest dimensions is very low, at just 2.2 per thousand of the rate for distribution system operators.

The quantity and quality of the statistical data that is now available means that the information that is to hand provides a vital framework for decisions on rehabilitation issues for gas system operators in Germany. Taking their lead from DVGW Bulletin G403 1), companies can match these changes in the rates of incidents with their own data with a view to updating their renewal and maintenance strategies if need be.

Furthermore, besides the evaluation and analysis of security-relevant operating statistics communication and reporting have a major significance. Regarding gas incidents and accidents the prompt availability of information is a substantial requirement in order to be able to give statements opposite market partners, the public and legal authorities and in order to specify causes and give professional assessments.

1) 'Decision Support For The Maintenance Of Gas Distribution Networks'

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[7] BDEW Bundesverband der Energie- und Wasserwirtschaft e.V.: Gaszahlen – Der deutsche Erdgasmarkt auf einen Blick.

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THE INTEGRAL DVGW SAFETY CONCEPT FOR CONSTRUCTION, OPERATION AND MAINTENANCE OF HIGH-PRESSURE GAS PIPELINES

Anika Groos, Detlef Jagozinski > DVGW
Michael Kurth > Gasunie Germany
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ABSTRACT

The construction, operation and maintenance of high-pressure gas pipelines require conscientious planning and execution, taking numerous aspects into account. The focus must always be on ensuring that the surrounding is not impaired and that the safety of people and the environment is not endangered. In order to guarantee this, the DVGW rules and regulations form an integral safety concept, which is in a continuous adaptation process, so that it can be ensured that the pipelines correspond to the state of the art.

DVGW REGULATIONS DEFINE STATE OF THE ART FOR HIGH-PRESSURE GAS PIPELINES

According to the Ordinance on High Pressure Gas Pipelines (GasHDrLtgV), high pressure gas pipelines for the transport of natural gas at pressures above 16 bar in Germany must be constructed and operated in such a way that they do not impair the safety of the surroundings and do not have a harmful effect on people and the environment [1]. Section 2 of the GasHDrLtgV assumes that construction and operation are state of the art if the rules and regulations of the German Gas and Water Association (DVGW) are observed. The state of the art required for this is anchored in the DVGW regulations, in particular in DVGW Codes of Practice G 463 and G 466-1 [2, 3]. These two Codes of Practice describe the construction, operation and maintenance of high-pressure gas pipelines in detail.

In the course of the regular revision, the safety philosophy of the DVGW regulations and the corresponding technical regulations were adapted in various project groups to the state of the art for high-pressure gas pipelines for transporting natural gas at pressures above 16 bar. The overall process of transporting gaseous natural gas through underground high-pressure gas pipelines was considered, i.e. from route planning, construction, operation and maintenance. In some cases, the project groups - e.g. for technical safety - were staffed on an interdisciplinary basis by:

- Legislation - Federal Ministry of Economics and Energy (BMWi)
- Enforcement Agency - Energy supervision authorities of the federal states, Bavaria, NRW, Saxony
- Experts – DVGW, TÜV Nord
- Science - Universities, KIT-Karlsruhe, TU Clausthal
- Rule Setters – AfR, DVGW
- Federal Agency - Federal Institute for Materials Research and Testing (BAM)

During the revision, the corresponding DVGW codes of practice were adapted to the state of the art for high-pressure gas pipelines. Additional international

> *"An evaluation of DVGW incident data collection up to 2014 indicates a very high safety standard and reliability as demonstrated for example by the sustained fall in the number of incidents. For example an almost 90% reduction in incidents on gas pipelines has so far been achieved since 1981 even though the total length of pipeline network has risen significantly.*
>
> **Dr. Michael Steiner**

standards and national codes such as the Technical Rules for Pipelines [4] were also taken into account. Furthermore, past incidents and events as well as current findings from the point of view of safety engineering were taken into account. Even though the quality of pipeline construction and operation is today extraordinarily high due to the continuous technical progress in the manufacturing and testing procedures and the fact that DVGW rules and regulations describe the safety requirements for the construction, operation and maintenance of high-pressure gas pipelines very comprehensively and concretely, the requirements are to be specified in more detail and more bindingly as far as reasonable.

Since the large number of technical specifications and preventive safety measures in the DVGW Standards and Codes of Practice are not marked as risk-reducing measures for the protection of man and the environment and are therefore not immediately recognisable to the layperson, because they are directly integrated into the process concept, the holistic DVGW safety concept will be explained in more detail here.

HOLISTIC DVGW SAFETY CONCEPT

The revised rules and regulations took into account the guard rails for safety-related topics laid down in the revised DVGW Rules of Procedure DVGW GW 100 [5]. Thus, the protection of man and the environment is to be ensured by the regulations. The deterministic safety concept will continue to be maintained, although individual probabilistic supplements are possible. The rules and regulations must reflect the state of the art of transport with high-pressure gas pipelines, including all sources of knowledge such as publications, international rules and regulations, experience, science and opinions. When establishing regulations, particular consideration shall be given to the results from incident statistics, e.g. DVGW inventory and event data acquisition according to DVGW Code of Practice G 410, incidents of gas pipelines according to DVGW Code of Practice G 411, European incident data according to EGIG [6, 7, 8]. The safety measures specified in the DVGW rules and regulations shall be binding, their effectiveness, availability and accuracy shall be evaluated and regularly compared with new sources of knowledge. Furthermore, the potential risk shall be considered with regard to the type, number and effectiveness of the protective measures and the protective measures already applied in practice by many operators shall be included in the regulations.

- A high-pressure gas pipeline must be able to withstand all expected loads during commissioning. Furthermore, the loading capacity and the operational and environmental loads must not change unacceptably over time. Also, additional unacceptable loads are to avoid. For this reason, changes in load and loading capacity must be checked in relation to condition and impact and countermeasures must be taken in the event of impermissible changes.
- Safety-related measures to avoid hazards caused (for example by the actions of third parties or environmental hazards such as ground movements) must be proven qualitatively in terms of their effect, accuracy and availability - for example statistically or by operational experience - whereby the quality of the measures is based on the possible effects.

Thus, according to the principle of inherent safety, hazards can be eliminated or their probability reduced for high-pressure gas pipelines by preventive protective measures such as high values of pipe covering, wall thickness or material toughness as well as by laying them in areas without hazards. An additional increase

> *"Open Grid Europe deploys a large number of different safety measures that are state-of-the-art for high pressures gas pipelines in Germany. These measures enhance the technical safety of high pressure gas pipelines by adding effective protection of the line from external interference, thereby creating one of the safest pipeline systems.* Dr. Michael Steiner

in safety is achieved if several independent measures are applied. Such measures can be grouped into layers of protection, whereby a distinction is made here between preventive safety measures and primary and secondary protective measures, dual strategy according to Figure 1 [13].

The application of these levels of safety to high-pressure gas pipelines results in correspondingly adapted measures for different hazards. The levels of safety are schematically summarised in Figure 2 as example of possible corrosion. Here, preventive structural measures, i.e. passive corrosion protection (coating) and active cathodic corrosion protection are combined with organisational protective measures, such as inspections and expert tests.

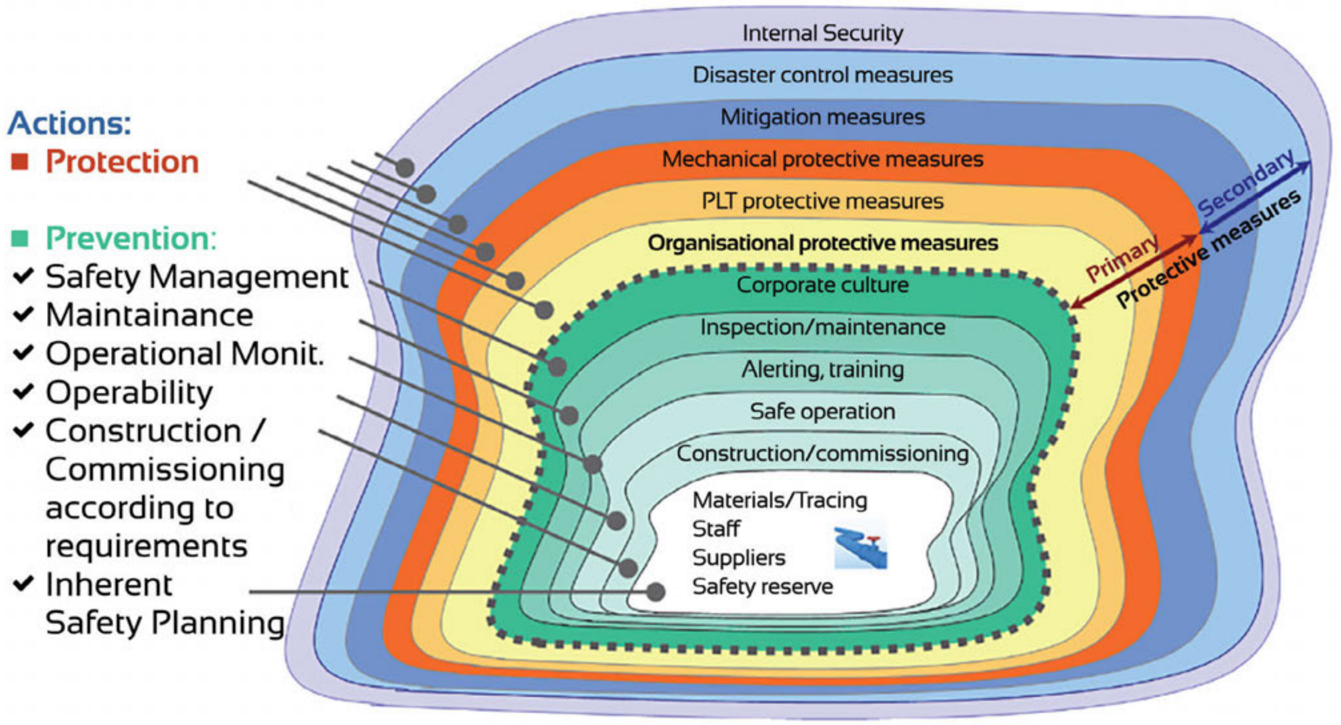

Figure 1: Layers of Protection for high-pressure gas pipelines [according to 13]

In order to systematically compare all possible safety aspects with the safety-related specifications or additional measures to protect the pipeline, a hazard analysis or safety study by independent experts is usual or an assessment can be carried out in accordance with DVGW Code of Practice G 1001 "Safety in gas supply - Management of risks" [14]. Since no methodology including limit values for a quantitative risk analysis is available for high-pressure gas pipelines in Germany, a qualitative assessment is recommended here.

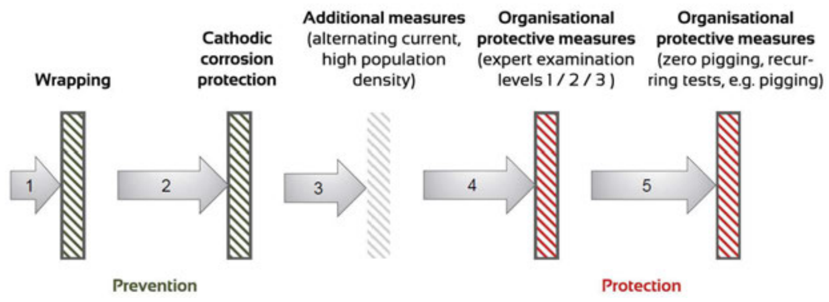

Figure 2: Layer of Protection for a risk of corrosion [according to 13]

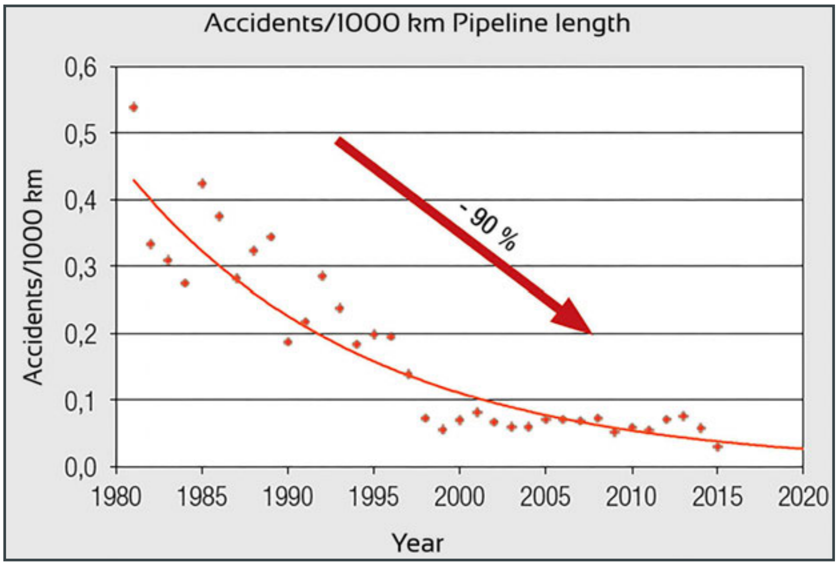

Figure 3: Incident development since 1981 at gas pipelines of all pressure levels [15]

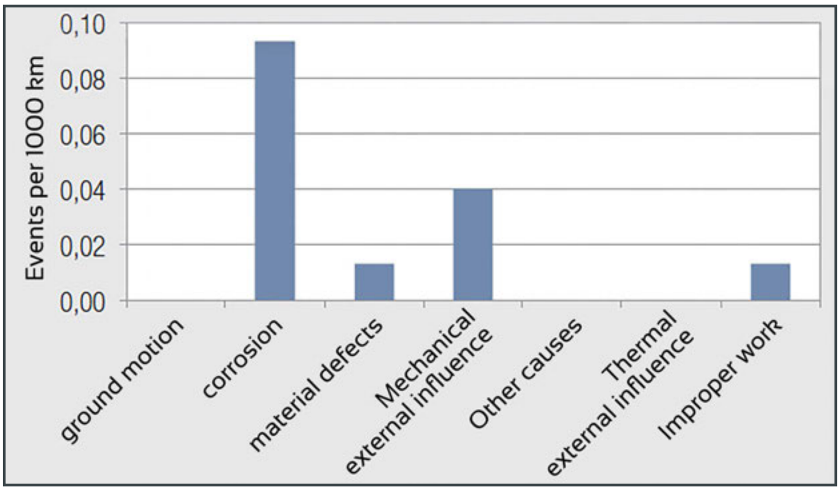

Figure 4: Incidents per 1000 km for pipelines of transmission system operators above 16 bar [16]

ADAPTATION OF THE DVGW REGULATIONS BASED ON OPERATIONAL EXPERIENCE

Since the results from incident statistics are to be considered, all serious events with unintentional gas release and all identified safety-endangering interventions in the area of influence of the pipeline are to be analysed with regard to the cause in accordance with DVGW Code of Practice G 466-1 and necessary measures for future avoidance are to be derived [3].

The new version of DVGW incident data acquisition for events with unintentional loss of gas already takes the DVGW guard rails into account in its evaluation of safety measures and the update of the state of the art.

For example, the evaluation of recording until 2014 shows a very high safety standard and a very high reliability, which can be demonstrated, for example, by the continuously decreasing number of events [15]. Thus, from 1981 to the present day, it has been possible to achieve an almost 90% reduction in the number of incidents on gas pipelines, even though the length of the pipeline network has risen sharply at the same time (Fig. 3).

Figure 4 shows the distribution of all immediately reportable event causes for high-pressure gas pipelines of more than 16 bar. The majority of the events are caused by corrosion leaks and, in second place, by mechanical external influences. Material defects and improper work (e.g. assembly and construction defects) follow together in third place.

The detailed consideration of the distribution of events subject to immediate reporting which are associated with personal injury, deflagration, explosion, fire, flying debris or other public events is shown in Figure 5. The main cause of immediately reportable events on high-pressure gas pipelines above 16 bar is 74% of mechanical external events, followed by 16% of thermal external events.

As in the case of the serious events from the European damage statistics EGIG, the immediately reportable events for the mechanical external impacts of gas pipelines above 16 bar in Germany also rank first, but are far below the European value in the per mile range. Serious events for ground movements and manufacturer errors did not occur in Germany during the period under consideration. While the main cause of the events for gas pipelines above 16 bar in Europe is damage by third parties, for pipelines above 16 bar in Germany this is corrosion leakage, which can be explained by the fact that some of the gas pipelines in Germany are much older than those in Europe.

Since, according to DVGW Code of Practice G 466-1, all possible safety-relevant aspects have to be taken into account when determining safety-related measures for construction, inspection and maintenance [3], the consideration of past events results in a focus on measures for the protection of the pipeline against corrosion leaks and manufacturer/construction faults as well as, in particular, damage from the outside or due to soil impacts. As measures for the protection of the pipeline, additional mostly structural measures during construction, e.g. marking of the pipeline route, as well as predominantly organisational measures for the existing pipeline, e.g. recurrent inspection, especially in areas with an increased need for protection, should be taken. Such areas with an increased need for protection are, for example, built-up areas or areas to be newly built, areas of intersections with traffic routes or areas in which additional impacts on the gas pipeline are to be expected. The measures taken to protect the pipeline minimise the probability of occurrence and thus the risk of an incident.

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STATE OF THE ART FOR THE CONSTRUCTION OF HIGH-PRESSURE GAS PIPELINES

The revised Technical Regulation for the Construction of New High-Pressure Gas Pipelines, DVGW Code of Practice G 463, focuses on safety measures on structural measures. For example, the safety and protection of people and the environment must be taken into account when routing high-pressure gas pipelines. Among other things, the future operation of the pipeline, existing soil conditions and possible third-party influences must be taken into account.

In DVGW Code of Practice G 463, for example, the following protective measures were increased in comparison with other standards for the construction of high-pressure gas pipelines:

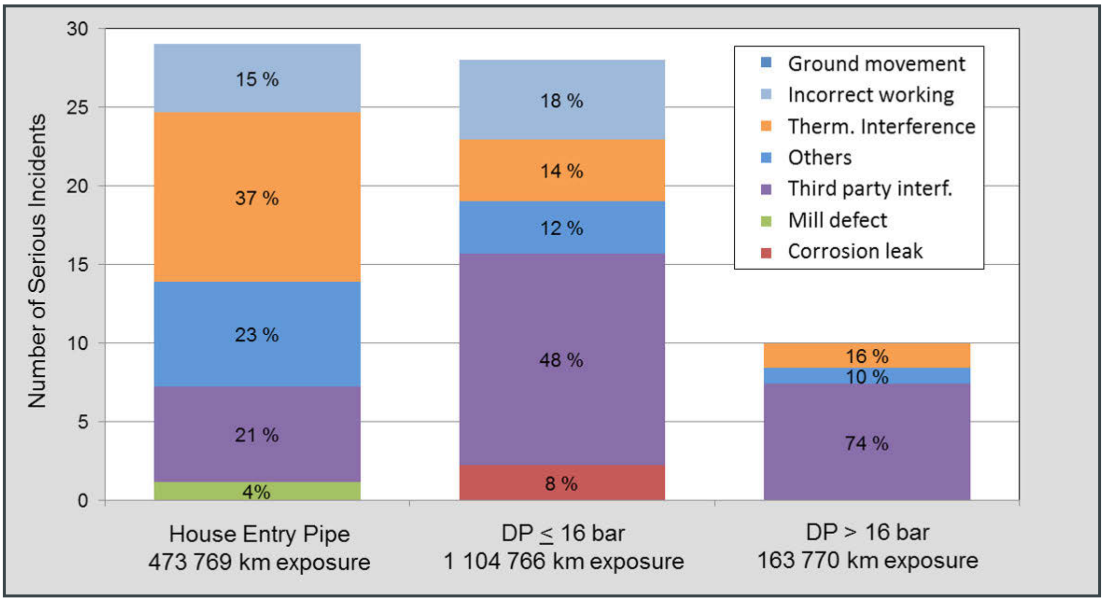

Figure 5: Distribution of all immediately reportable events to house connections and pipelines [16]

- Safety coefficient minimum of 1.6 (usage factor of maximum 0.625)
- depth of cover minimum 1 m
- 100% of girth welds to be checked
- increased amount of marker posts in areas of dense population
- increased hydrostatic test in areas of dense population
- use of ductile linepipes acc. to DIN EN ISO 3183, attachment M, PSL 2

In addition, higher requirements are specified in built-up areas. For example, a more dense marking of the pipe routing, e.g. by sign posts, must be provided and the pipe must be subjected to a water pressure test according to the pressure/volume measurement method D2 in accordance with DVGW Code of Practice G 469 [17] or VdTÜV Code of Practice for Pipe 1060 [18]. After the test according to the pressure/volume measurement method D2, the geometry test for corresponding geometrical deviations including limit values is specified in DVGW Code of Practice G 463.

Where possible and proportionate, the line should be laid out in such a way that no additional protective measures are required. If routing is carried out in areas with an increased need for protection, e.g. in built-up areas or in areas in which additional impacts on the high-pressure gas pipeline are to be expected, individual additional protective measures shall be provided. These measures must be weighed against each other depending on the type of area and the potential hazard. Such individual measures may be, for example, the increase of safety factor, depth of cover, pressure test requirement, marking or scope of testing or the provision of a route warning tape or geotextile [2]. If, on the other hand, a new high-pressure gas pipeline is not routed through a built-up area, no additional measures are required. In order to protect the pipeline, DVGW Code of Practice G 463 specifies the distance to underground installations, high-voltage installations and wind turbines.

STATE OF THE ART FOR OPERATION AND MAINTENANCE OF HIGH-PRESSURE GAS PIPELINES

The Technical Rules for the Operation and Maintenance of High Pressure Gas Pipelines DVGW Code of Practice G 466-1, on the other hand, places the safety-related emphasis on organisational measures such as condition-oriented inspections and shortened inspection intervals (e.g. inspection cycles within counstruction). When defining and carrying out the inspection and maintenance measures, possible safety-relevant aspects have to be considered. These include, among other things, external impairments, e.g. due to construction activities, soil movements, corrosion, manufacturing defects and leaks. Typical protective measures here are:

- Surveillance / Inspection by walking or helicopter
- Monitoring of cathodic corrosion protection
- Inline Inspections (intelligent pigging)
- Evaluation of ground movements
- Monitoring of construction activities in the vicinity of pipelines

The basic requirement for systematic consideration is to apply suitable quality assurance and management systems and, in particular, a pipeline integrity management system, e.g. PIMS according to [19]. Such a PIMS is to be understood here as a series of suitable activities and procedures by which an operator maintains the integrity of the gas pipeline in order to ensure safe and reliable operation.

One focus of the safety-related specifications concentrates on corresponding cycles in particular for zones within built-up areas. Thus, adapted cycles for the secondary safety measure of route control are specified and in areas with an increased need for protection, recurrent proof of the effectiveness of corrosion protection according to DVGW Code of Practice GW 10 [20] is required. This strengthens the role of the experts [21 - 24]. Piggable high-pressure gas lines are also condition-oriented and repeatedly have to be inspected. Typical cycles for a repeated, here newly defined "Intensive CP measurement technique" as well as inline inspection are 10 to 25 years. Furthermore, the DVGW and the operators of high-pressure gas pipelines support safety measures to prevent damage by third parties. These include BALSibau for damage minimisation during construction [25, 26] and the "Bundesweite Informationssystem zuzr Leitungsrecherche" (nationwide information system for pipeline research) BIL [27].

In areas with an increased need for protection, e.g. in built-up or newly constructed areas or in areas in which additional impacts on the high-pressure gas pipeline are to be expected, shortened inspection cycles or improvement measures may have to be provided depending on the type of area and the potential hazard. On the one hand, in accordance with DVGW Code of Practice G 466-1, the time intervals of inspection and maintenance measures shall be appropriately specified with regard to the condition, taking into account the operating experience and the local conditions [3]. On the other hand, in areas with an increased need for protection, e.g. in areas with approaching or already approached constructions and in areas in which additional impacts on the gas pipeline are to be expected, a more dense marking by marker posts or signs and, if necessary, with increased warning notices and information, shall be provided as a preventive measure. In accordance with DVGW Code of Practice G 463, these new marker posts or signs must always be placed on the line axis and within sight of each other. If this marking is removed from the line axis due to local conditions, the direction and distance to the line axis must be specified [3].

ONGOING ACTIVITIES

In the course of the ongoing updating of the DVGW code of practice, the safety specifications on the topics of operational inline inspections (DVGW Code of Practice G 450), measures for construction work (DVGW Information GW 315) and principles and organisation of on-call service (DVGW Code of Practice GW 1200) are currently being revised. In DVGW project groups, the systematic evaluation and justification of safety-related specifications for construction, operation and maintenance as well as the investigation of events by third parties are also performed.

SUMMARY AND CONCLUSION

The revision of DVGW Codes of Practice G 463 and G 466-1 shows that the integral safety concept for high-pressure gas pipelines presented here, based on the DVGW rules and regulations, has proven its worth in operation, so that pipelines laid accordingly are technically safe. Nevertheless, they must continue to be protected against external influences. For this reason, the DVGW Standards and Codes of Practice specify a high level of technical safety equipment as well as measures to protect the line from external influences.

From the consideration of past events, the main focus for measures to protect the pipeline is on corrosion, material defects and external damage. To protect the pipeline, therefore, additional measures are specified, usually structural (e.g. increased water pressure test with stresstest) for the construction of the pipeline and mainly organisational (e.g. repeated inspections in areas with an increased need for protection, e.g. within buildings) for the existing pipeline.

In summary, it can be seen that the current DVGW Standards and Codes of Practice contain numerous preventive safety-related provisions according to the state of the art for high-pressure gas pipelines in Germany. With these measures, the technical safety of high-pressure gas pipelines is supplemented by the effective protection of the pipeline against external influences and the framework for one of the safest pipeline systems is given.

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THE ADVANTAGES OF DVGW TSM – A TECHNICAL SAFETY MANAGEMENT SYSTEM

Peggy Zeppei > ONTRAS Gastransport

ABSTRACT

Companies that operate technical systems, e.g. the German gas transmission system operator ONTRAS Gastransport GmbH, must ensure operational safety at all times, that all associated procedures and processes comply with the applicable laws and regulations, and that the company is also prepared to react in case of emergencies. Haphazard trial and error might be a possibility to achieve this. However, considering that the methods used should fit process control as well as legal requirements, some kind of organised management system featuring concrete steps in a predefined order is necessary. A practicle example is the QM System of ONTRAS.

THE ADVANTAGES OF DVGW TSM – A TECHNICAL SAFETY MANAGEMENT SYSTEM

Companies that operate technical systems, e.g. the German gas transmission system operator ONTRAS Gastransport GmbH, must ensure operational safety at all times, that all associated procedures and processes comply with the applicable laws and regulations, and that the company is also prepared to react in case of emergencies. Haphazard trial and error might be a possibility to achieve this. However, considering that the methods used should fit process control as well as legal requirements, some kind of organised management system featuring concrete steps in a predefined order is necessary. In order to build up such a system, it is best to start with a plan that sets defined targets. In the first instance, the individual steps for various procedures are analysed to define the processes. After implementation, it is necessary to develop a comprehensive review process that determines which envisaged goals have been achieved and to what extent. The results of this review process will make it possible to adapt or correct processes, where necessary. It is important to document all the steps and resulting processes as well as implementation methods and progress.

> *TSM Systems provide processes to ensure a safe operation and to minimize risks of organisational faultssystems.*
> Peggy Zeppei

GENERAL REMARKS

All the management systems presented here follow the same scheme (fig. 1):

- Plan: Defining targets and the action required for implementation
- Implement: Installing the planned steps to achieve the envisaged targets
- Check: Checking to be sure that the implemented action generates the expected effect
- Act: Learning from and improving the system continuously

There are two groups of common management systems:

- Management systems for defining and improving a company's quality and safety of processes: Quality (and safety) management systems (QM)
- Management systems to minimise risks of organisational faults: Technical safety management systems (TSM)

QUALITY AND SAFETY MANAGEMENT (QM)

There are several standards that fulfil quality and safety requirements. Most important, nationally and internationally, is the common standard ISO 9001 from 2015. It covers quality management (QM) and aims at a continuous improvement of the company's internal quality management system. ISO 9001 is process-oriented and specifies the minimum requirements for a quality management system. A QM system of this kind should enable an organization to, at least, reduce its error rate and resultant costs.

Another commonly used standard is ISO 14001, last updated in 2015. It defines the requirements for the certifiable environmental management system (EMS) of an organisation. The standard should allow an organisation to continuously improve its environmental impact, achieve compliance with legal and other environmental requirements, and reach its environmental objectives. Therefore, the organisation needs to identify its significant environmental aspects and the associated impacts as well as suitable criteria for controlling the environmentally relevant processes. This standard also monitors whether the environmental goals have been achieved and documents the continuous improvement with suitable indicators.

A common standard for occupational health and safety (OH&S) is OHSAS 18001. It defines the requirements for the occupational health and safety management system of an organisation. These requirements include, for example, a suitable OH & S management system, including mechanisms for organising occupational health and safety and its hazards and risks within a company.

TECHNICAL SAFETY MANAGEMENT (TSM)

Technical Safety Management Systems aim to minimise risks of organisational faults. The German DVGW TSM system is based on compliance with laws, regulations and the generally accepted rules of technology that apply

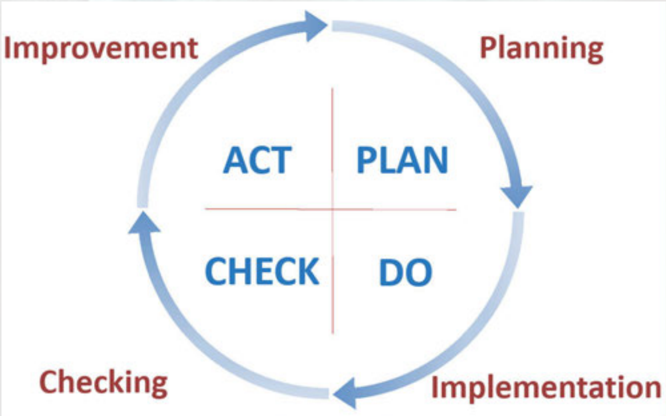

Figure 1: TSM implements a continious cyclic process of planning, checking and improving

throughout the industry and are the same for all companies. Thus, the technical rules and DIN standards of the German DVGW regulations provide legal certainty and a basis for all activities in the gas industry. The advantage is that as an association, the DVGW acts economically independently, neutrally and is not profit-oriented. Thus, the DVGW ensures transparent rulemaking processes.

For ONTRAS as Germany's second-largest transmission system operator, the relevant TSM regulations are the technical rule G 1000 from 2005 defining requirements for the qualification and organisation of the normal operation of gas infrastructure, and the technical rule G1001 from 2015 defining the risk management of the technical gas infrastructure. As the company is also responsible for operating 22 biomethane injection plants, the technical rule G 1030 from 2010 is also relevant defining the requirements for organisation and qualification of operators of biogas plants.

In detail, the TSM of the DVGW (referred to from here on as "TSM") comprises a process of constant updating to reflect the latest statutory requirements. As a management system for technical safety, it has been well established in the German utilities industry since 1999. It provides an outstanding component of technical self-administration in the energy industry and is essentially based on the know-how and the engagement of the experts of the sector. A regular recertification process provides systematic updates of the whole system and its benefits.

TSM focusses on the organisation of the company. Like the camera in a classic Hollywood movie that zooms from a wide angle with landscape, horizon and people into the smallest detail, in the total view TSM analyses the organisational structures and looks for clear definitions of technical disciplinary responsibilities and functions. It prevents in particular an overlap in competence, being one of the main causes of faults. Zooming in, TSM considers the processes within the organisation and the departments of the company. It looks for the acquisition of important work processes, the coordination among involved units of the organisation and aims to create transparent processes that can be updated if necessary.

In order to help a company in establishing its individual TSM system, DVGW offers a wide range of guidelines with checklists and questionnaires. These aids can assist the respective company to systematically review its structural and procedural organisation by self-assessment.

ONTRAS TSM AND RELATED DOCUMENTS

Since its foundation in 2006, ONTRAS has been developing its own company rules and regulations for relevant standards in addition to or due to a the lack of existing regulations. We do this in order to ensure that all our

> *"With such a system a company ensures professional reaction during normal operation and in cases of emergency.* Peggy Zeppei

documents fit perfectly to our business needs. Typical applications include:

- checklists for construction site inspections, also available as an app
- various documents for the cooperation with service providers
- audit of service providers according to ISO 9001
- question catalogue for service providers, e.g. checklists for on-duty vehicle equipment
- ONTRAS regulations for service providers regarding on-call service and maintenance
- on-call service organisation
- operating instructions for the operation/maintenance intervals of biomethane plants,
- concrete regulations for liquefied petroleum gas suppliers (e.g. safety plan for LPG filling)
- comprehensive service contracts using the SAP-system (access for service providers - activation orders and billing)

Example 1: Construction Site Inspection

Our construction site inspection app for iPhones helps auditors with their work in the field. Detailed and easy to handle checklists guide them through their tasks and document all the steps and results transparently (fig. 2).

The auditor has to check, among others:

- Whether site documentation is available and complete.
- Whether site equipment/first aid equipment is satisfactory.
- Whether fire protection has been correctly organised and equipment and information about this are available.
- Whether hazardous substances are present, and if so, whether they are being properly handled.
- Whether the necessary materials are available and are properly stored.
- Whether the security of the site is satisfactory.
- Whether scaffolding, ladders and stepladders are available and in the right place.
- Whether the people at the site use their personal protective equipment correctly.
- ...
- Whether construction machines (such as diggers, cranes, and drilling instruments) are satisfactory and are properly positioned.

Example 2: Check-Up of On-Call Duty Vehicles

ONTRAS has developed another app to check on-call duty vehicles.

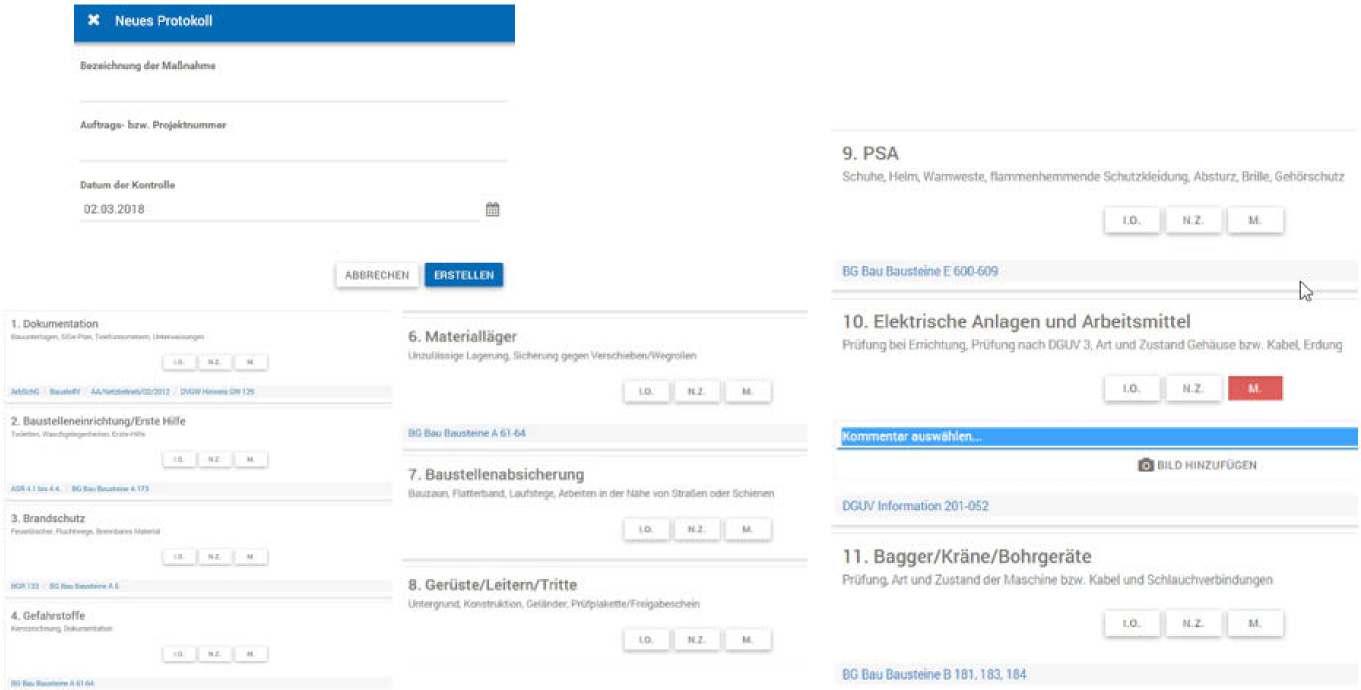

Figure 2: A systematic check list provides easy and quick handling of site checks

The app considers the on-call schedule (timeliness/up to-date, telephone list) and whether a mobile phone is on board. It enables the user to determine quickly whether the respective vehicle is properly equipped by checking the barrier materials, measuring equipment, emergency lighting, tool kit, plans and documentation, camera and other photography equipment, fire extinguisher and so on.

HOW THE TSM CERTIFICATION PROCESS WORKS

How the process of a typical TSM audit works and how to get the envisaged certificate is explained using the example of ONTRAS TSM certification.

After the company indicates to DVGW its intention to be TSM certified, it receives an examination catalogue with the respective guidelines. On this basis, the company answers an extensive questionnaire for preliminary examination and prepares the requested documents, such as organisational charts, organisation of departments, relevant regulations among others. In the first audit, the DVGW auditors will randomly test the resulting documents during several examination talks and look at specific processes in detail. Afterwards, the auditors will give their first impression and present initial results of their examination. If everything was as expected and all results were positive, DVGW will send the complete examination report along with the coveted TSM certificate that is valid for at least two years. After expiry, it has to be renewed by a new audit that will mainly focus on selected processes. If the result of the first audit is negative, the company may repeat the whole process, taking into account the first audit results and trying to update and optimise the negatively rated processes and documents.

"The systematic approach enables a continuous learning from and improvement of the processes and further education of employees.

Peggy Zeppei

By certifying its TSM system, ONTRAS improved the safety of its employees, its transmission system and facilities whilst also minimising the organisational risks and organisational negligence. Furthermore, interaction with our service providers is much easier and the involved processes are more transparent. The introduced comprehensive site inspection system avoided technical faults and violations of legal as well as internal regulations. For example, in 2017 we inspected about 880 construction sites and registered approx. 80 findings, most of which could be quickly eliminated. Generally, it makes sense and is cheaper to prevent incidents before they occur than to deal with the consequences afterwards.

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ENHANCED SAFETY THROUGH EXPERT ASSESSMENTS

Christian Engel > TÜV NORD Systems

ABSTRACT

In the construction of pipelines for the transport and storage of combustible, corrosive or toxic gases and water-polluting fluids, independent inspections by experts is an essential aspect of quality assurance which contributes significantly to the safety of these systems. This does not only apply to new projects, but also to modifications, conversions or maintenance measures. This approach has proven itself in Germany for many decades and contributes to making these systems some of the safest in the world.

REQUIREMENTS ACCORDING TO THE TECHNICAL REGULATIONS

Different laws, regulations and technical rules apply to the various types of pipeline systems in Germany depending on the medium being transported. In the area of public gas supply, the UVPG (Environmental Impact Analysis Act), the Ordinance Regulating High Pressure Gas Pipelines and the DVGW (German Technical and Scientific Association for Gas and Water) regulations are applied in conjunction with relevant DIN EN standards, e.g. DIN EN 1594. With regard to construction supervision and inspections by experts, the DVGW worksheets GW 350, G 434, G 462/I, G 462/II and G 463 as well as the VdTÜV data sheet on pipelines 1001 are to be mentioned here.

For other pipelines, e.g. the transport of water-endangering substances or flammable gases which do not serve to supply the general public, the UVPG, the Pipe Transmission Ordinance and the TRFL (Technical Rule for Pipelines) apply.

For pipelines and installations in the field of oil and gas storage systems, the requirements for mining law are additionally applied. For lines which run exclusively within factory premises, requirements for the tests of the Pressure Equipment Directive and the Operational Safety Ordinance are applied.

Quality monitoring by experts accompanies the above described plants/systems over their entire life cycle: starting with planning and approval procedures, via construction, commissioning and operation to decommissioning. The quality monitoring measures by independent experts in the various phases are described in the following sections.

QUALITY MONITORING BY EXPERTS

PLANNING AND APPROVAL PHASE

Independent experts may carry out studies on safety and feasibility even during the planning and approval phase. A higher degree of acceptance for public projects or also greater legal certainty in the approval procedure, for instance, can be attained in the process.

The examination of the notification or approval documents by independent experts usually leads to an even smoother course of the notification or approval procedure by the competent authority. Here, obvious errors or other deficiencies can be corrected before the documents are submitted, which can significantly reduce the official approval procedure time and effort.

> “*Quality monitoring by external experts accompanies the pipelines in Germany over their entire life cycle, starting with planning and approval procedures, via construction, commissioning and operation to decommissioning.*
> Christian Engel

CONSTRUCTION

Within the framework of construction, independent experts assess the qualifications of the companies involved (pipeline construction, corrosion protection, non-destructive tests) and the personnel employed, the quality of the construction work, including non-destructive tests, pipe laying and coating. The basis for the tests to be performed is the VdTÜV-Merkblatt Rohrleitungen (data sheet on pipelines) 1001.

After the pipeline has been laid properly and the construction examination has been completed, the pipeline is subjected to a cohesive or partial strength test and leak test (pressure test). This pressure test is the integral proof of the proper construction and laying of the pipeline before its commissioning.

By performing the construction and pressure test by independent experts, it is ensured that a high-quality pipeline is produced which in later operation can result in lower costs and can be safely operated.

COMMISSIONING

Before commissioning, the necessary safety devices of the pipeline system are checked by independent experts with regard to the suitability of the equipment used, the setting of limit values and the functional capability of the safety devices.

This ensures that all the important equipment of the pipeline system is suitable and safe to operate so that, for example, unacceptable operating conditions can be reliably prevented and, where appropriate, leakages can be reliably detected. The tests also include the explosion protection of the installations.

> “*By performing the construction and pressure test by independent experts, it is ensured that a high-quality pipeline is produced which in later operation can result in lower costs and can be safely operated.*
> Christian Engel

OPERATION

During operation, pipelines which are subject to the Pipeline Directive are inspected every two years by independent experts. Installations subject to mining law are also tested on a regular basis.

The tests cover the condition, the proper functioning of the safety devices and the CP (cathodic protection) as well as the tightness of the pipeline.

Furthermore, a multitude of further quality assurance tests can be performed by experts. These range from the selection and verification of suitable pipeline inspection tools (ILI) via the qualification of the inspection tools and the evaluation of the results of inspection tools, to service life estimates and damage investigations.

In the case of modifications in the pipeline environment, e.g. construction of new buildings, construction of new roads, etc., the expert's opinions can be used to ensure the safe condition of the pipeline by which certain measures established by the expert are taken to secure and protect the pipeline.

DECOMMISSIONING

In the context of decommissioning, proper drainage and cleaning is controlled by experts in the case of certain pipelines; in particular, pipelines for the transport of water-endangering substances. This ensures that there is no danger to persons or the environment due to the shut-down of pipeline sections.

IMPACT OF QUALITY MONITORING

Quality monitoring by experts leads to a reliable, high-quality transmission pipeline with a long service life and low costs during operation. The involvement of independent experts also minimises the liability of the owner/operator, since gross negligence is generally to be excluded.

Even if quality monitoring can never be completely comprehensive and can only be carried out in random samples, a higher quality can be achieved by means of concrete detection of errors and the timely introduction of corrective measures. Furthermore, a psychological effect comes into play because, as a rule, all parties concerned deliver higher quality when it is known that monitoring is carried out by an independent third party. Moreover sometimes the other perspective and/or the expert's experience also helps to detect, uncover and correct mistakes.

> *"Quality monitoring by external experts leads to a reliable, high-quality transmission pipeline with a long service life and low costs during operation.*
> Christian Engel

REQUIREMENTS FOR EXPERTS

Owing to the diverse tasks at all stages of the life cycle of a pipe transmission system, experts must have broad training and sound expertise. Experts must therefore undergo an extensive training program before they are authorised to perform independent tests. Expertise must be kept up-to-date by means of regular further training. It is also desirable to have a strong service provider mentality, since the tasks rarely take place near one´s place of residence, not always in good weather nor during normal working hours. Since certain decisions must be taken and implemented, conflict management and powers of self-assertion are among the optimal qualities of a good expert. Other characteristics include perseverance and reliability and a certain flair for tact is also necessary when communicating test results.

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BIL – THE GERMANY-WIDE INFORMATION SYSTEM FOR PIPELINE ENQUIRIES

Jens Focke, Ingo Reiniger > BIL - Federal German Construction Enquiry Portal

INTRODUCTION

The foundation of BIL eG by 17 German pipeline companies from the chemical, high-pressure gas and mineral oil sectors on 15 June 2015 cleared the path for developing the national information system for pipeline enquiries, BIL. With the implementation of an internet portal and a database backend, at the start of 2016 BIL will provide the first cost- free portal for information on pipelines in Germany.

MOTIVATION FOR ESTABLISHING BIL

BIL eG is a registered, non-profit cooperative. The organisational form of non-profit registered cooperative (eG) provides the necessary secure legal framework. In addition, the eG legal form promotes the joint endeavours of all involved parties in making building activities safer and is intended to motivate pipeline, utility and telco companies from all sectors, who can join the cooperative as members, to support this initiative. BIL does not pursue any commercial interests and will collaborate with operating companies and system providers. BIL will provide free information on pipelines and cables to enquirers.

BIL-member companies (as of 10/2018)

- » 66 participating companies
- » Liquid Pipeline Operators
- » Gas transmission Operators (TSO)
- » Water Transmission Operators
- » Wind and Solar
- » Multi Utilities
- » Cable Operator
- » High Voltage Transmission Operators

- » over 120.000 enquiries since operational start
- » > 500 enquiries /week in 2018
- » 13.000 registered users

Illustration 1: Member typ and BIL-achievements till start of operation

As pipeline operators, the founding members of BIL eG have had particular problems with the construction industry's lack of knowledge on the location of pipelines: often they are affected years later if damages to the subterranean pipeline infrastructure are detected during monitoring and inspection measures. In addition, undesirable costs may be incurred if civil protection operations need to be carried out, especially in rural

> *"The cost of compensating damage to pipelines caused by construction work amounts to an estimated €2 billion per annum. Much of this damage is due to a lack of information on the location of these assets.*
>
> *Jens Focke*

areas, when pipelines have been hit unexpectedly by a building contractor during earthworks. At the same time name changes, organisational changes and unknown boundaries to service zones do not make it particularly easy for the building industry to identify the relevant companies and contact persons. In these times of ever increasing construction activities, it is therefore necessary to standardise and simplify information requests on pipeline locations. BIL provides an internet-based – and thus permanently available – process, built on digital processing of location information using IT-based work(-force) management systems. BIL aims to incorporate the operators' existing planning information solutions in order to provide a standardised, lean and digital enquiry procedure to the building industry.

FOCUSSING ON THE CORE PROCESS

BIL wants to focus on the core process of the enquiry itself and access the online planning information systems of the operators without interfering with the internal workflow implemented therein. The BIL enquiry platform will enable enquiring building contractors to enter their building request with all technical details and corresponding location information as a geographical building area. The enquiry will be passed on to all pipeline companies available via BIL. By comparing the building area to the service areas of the operators (which are invisible to the enquirer), BIL checks online who is responsible for the pipelines/cables in the area and then sends the enquirer a list of the relevant operator or operators. The operators in charge receive the information from BIL, check whether they are affected and communicate all information via the BIL portal. This way, the task of checking if pipelines/cables are affected remains with the operator and their planning information generates the relevant information for the enquirer.

Illustration 2: Core of the BIL enquiry process

COMMUNICATION AND INTEGRATION

The main tasks and function of the BIL infrastructure are the digital check of who is responsible for a certain area and communicating this information via the portal. To this end, operators simply need to enter their geographical area of responsibility in BIL, specified as a corridor around a pipeline or as an area surrounding their service area. The data is transferred to BIL in standard graphic data formats. It comprises self-defined area polygons only, no pipeline data and pipeline routes. Operators are responsible for entering and updating their geographical areas of responsibility.

If, on that basis, BIL identifies that an operator is responsible for a particular area, the operator has several options for incorporating the digital building request by BIL into its processes. The differences lie only in the way in which the system is integrated into their workflow. The operators themselves are responsible for analysing the information in their database as to which, if any, pipelines are affected:

- **Replying to the enquiry from the system of the pipeline company:** the digital enquiry (alphanumeric information and area polygon) can be transferred via a web interface directly to the operator's system where it will be checked if their infrastructure is affected. Once it has been confirmed in the operator's system that none of their pipelines are affected, a "not affected" reply can be sent back to the BIL portal instantly and passed on to the enquirer from there. The information exchange with the enquirer takes place via the BIL portal. This process can also be used by participants who do not have their own infrastructure and where this service is outsourced to an engineer's office or a group company.
- **Processing the enquiry by the operator directly via the BIL portal without system connection:** in this case the participating operator decides if their pipelines or systems are affected based on the coverage area stored in the system. A manually created "not affected" or "affected" reply to the enquirer, possibly with .pdf attachments, can then be entered in the BIL portal. In cases where the operator's infrastructure is affected, additional digital planning information may be sent along with the reply.

In either case BIL does not interfere with the operator's workflow for processing enquiries and checking if their infrastructure is affected. The system offers the added value of allowing the building industry to make individual requests and filter "non-responsibilities" online, and allowing pipeline operators/utilities to make information available in a digital, standardised format.

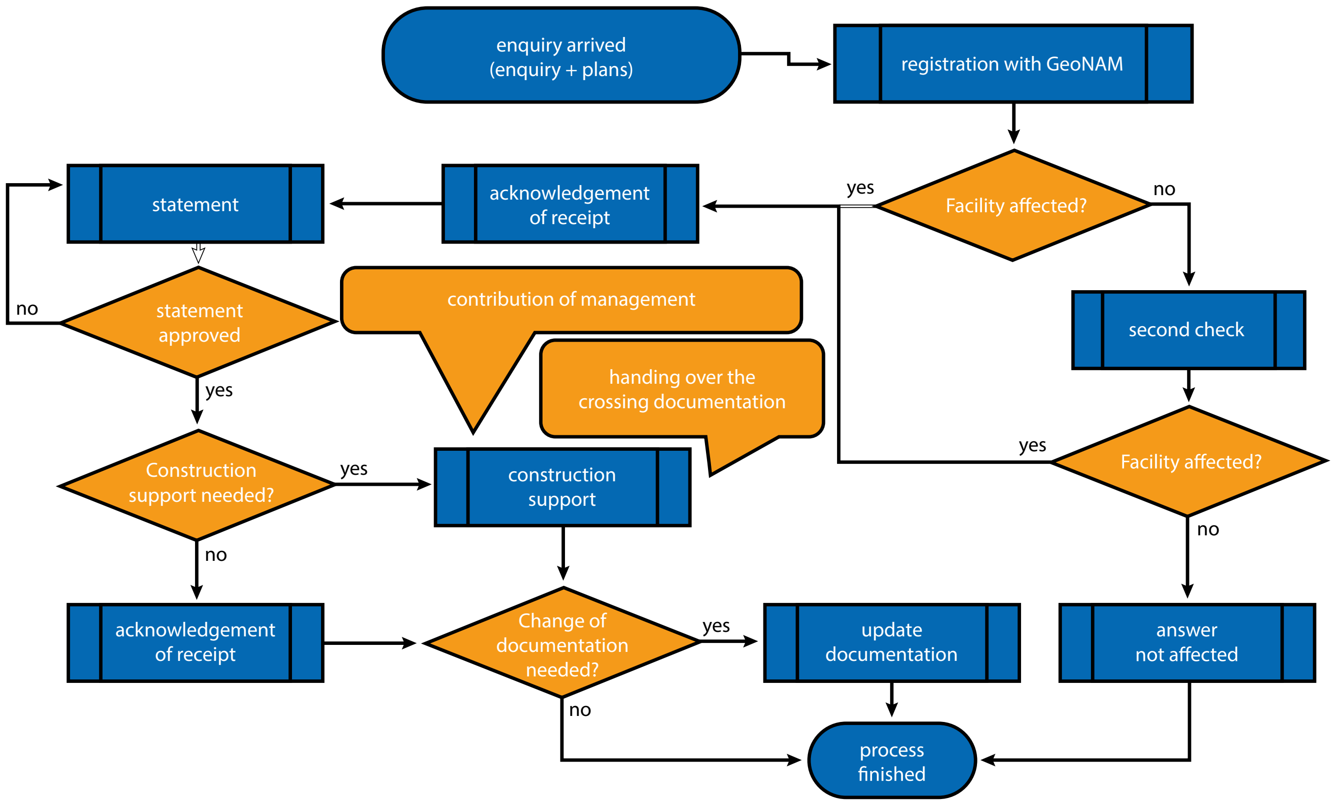

Illustration 3: Separation of BIL and operator's core process

TECHNICAL SCOPE

BIL provides a web-based information solution for enquirers (e.g. building contractors, planners, authorities etc.) and participants (pipeline companies) with the following functionality:

- interface for the building industry or other enquirers to request free information regarding all types of building work,
- communication platform providing the required information and documents,
- database function with geographical reference for integrating the operator's geographical area of responsibility to analyse potential responsibilities as part of a digging request.

The overall system is made up of the following three components:

- portal solution that can be accessed as a web service via the internet,
- database-driven information system for storing the participants' areas of responsibility (geographical situation of grid areas) and related information,
- integrated Web Map Services (WMS) for providing geographical reference data and maps,
- database backend for long-term storage of enquiry and information data from enquirers and operators.

The solution comprises the workflow between the enquirer and the participants as outlined in illustration 2 and 3 with the following additional features (examples):

Geographical context:
BIL requires the construction area to be entered as a spatial polygon based on map material including layout plans and official maps. The coordinate system ETRS89 forms the geodesic basis.

Construction site classification:
the enquirer must inform operators about the type of construction work via BIL. BIL provides a list of different types of civil engineering work for this purpose. Each type of building work generates a buffer zone of a particular size around the construction site. Therefore the operators' geographical areas of responsibility are affected to different degrees by the various types of construction works. Naturally, larger buffer zones must be observed for extraordinary structures than for local construction work.

This way, operators can keep their areas relatively small without missing a relevant enquiry.

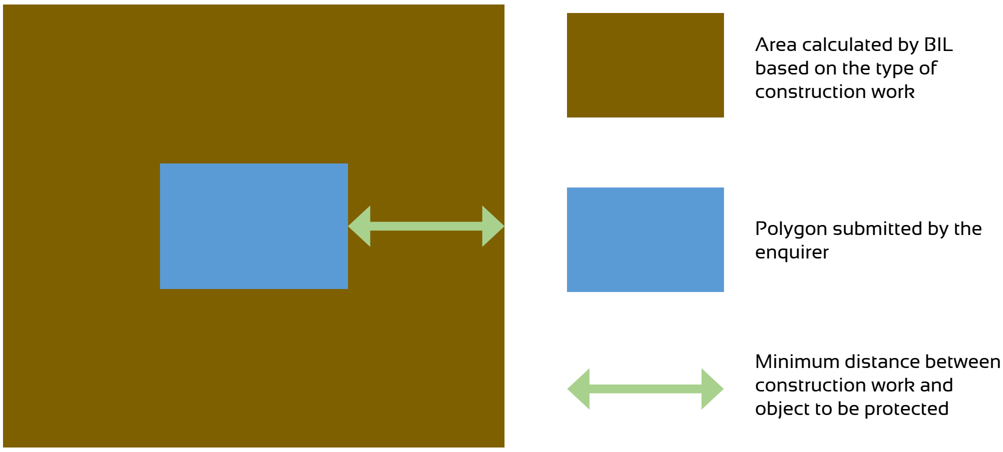

Illustration 4: Handling of construction criticality by corridors

Archiving: all data and documents are archived in line with the relevant legal provisions and kept for reference. Enquirers and operators may carry out research based on the data at a later time. Based on the collected data, statistical analyses in the form of monthly and annual reports can be generated in BIL.

BIL ACTS AS COMMUNICATION PLATFORM FOR ENERGY CHANCE DEMANDS

German high voltage transmission grid operators will increase their capacities along their routes to satisfy energy demands in southern Germany. By transmitting energy via overhead transmission lines electromagnetic interferences may interfere with the pipe body of pipeline operators. The technical framework demands all operators to exchange data of their route locations to analyse technical feasibility. For this issue locations of pipeline operators in between mast location must be identified within the so called spanfields. Only BIL may give detailed information by a special report listing names of pipeline operators and informing them about on-going studies of the high voltage transmission grid operators. Organised by German Amprion, as the largest of 4 high voltage transmission grid operators, leading pipeliners have confirmed their cooperation in sharing detailed route data via the BIL portal for this specific demand to accelerate the construction and optimization demands in Germanys "Energiewende".

BENEFITS

Increasing safety in civil engineering works is the main motivation of all the founding members of BIL eG and at the same time, it is an economic necessity gladly supported by the building industry.

Enquiries by the building industry are to be accommodated free of charge and in a technically attractive manner, with the objective of reaching more pipeline companies. Where information on the type of construction work is available from the enquirer and with a digital reply process on the operator's side, the functional aim is to consolidate enquiry and reply information in a digital workflow. This should help overcome any potential inhibitions with respect to making enquiries at any time and from anywhere. Preventing damages and operational faults adds economic value that may also contribute to increasing the much needed acceptance for necessary infrastructure projects.

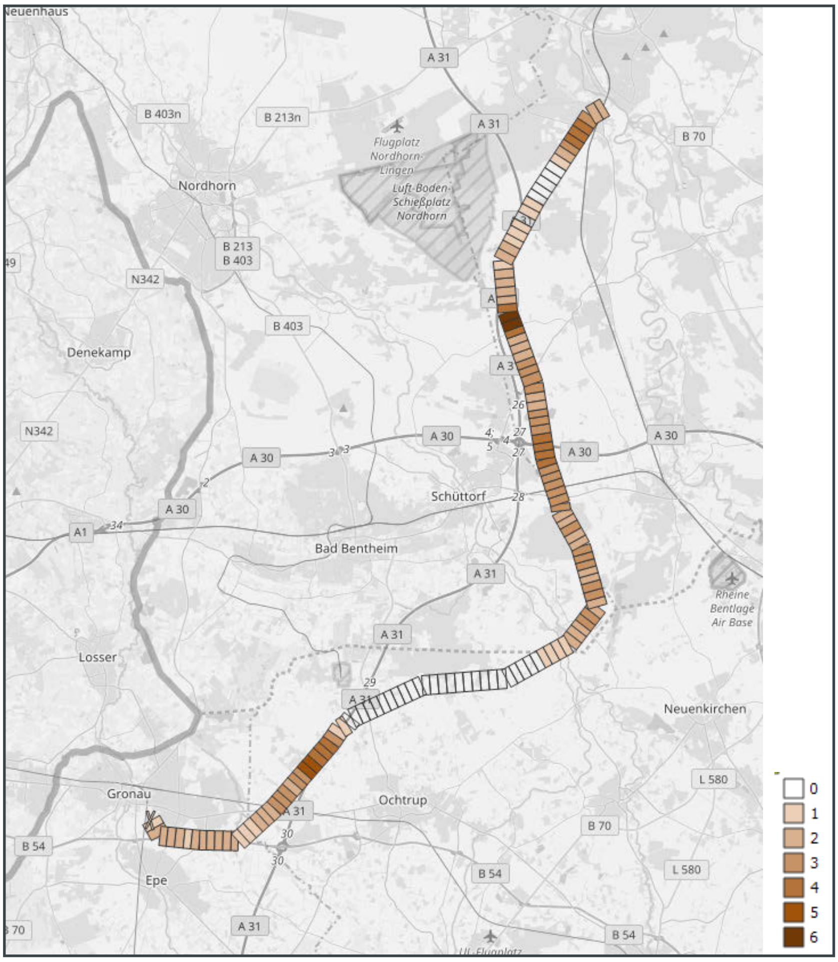

Illustration 5: Result of spanfield analysis showing coloured amount of identified operators within single spanfield

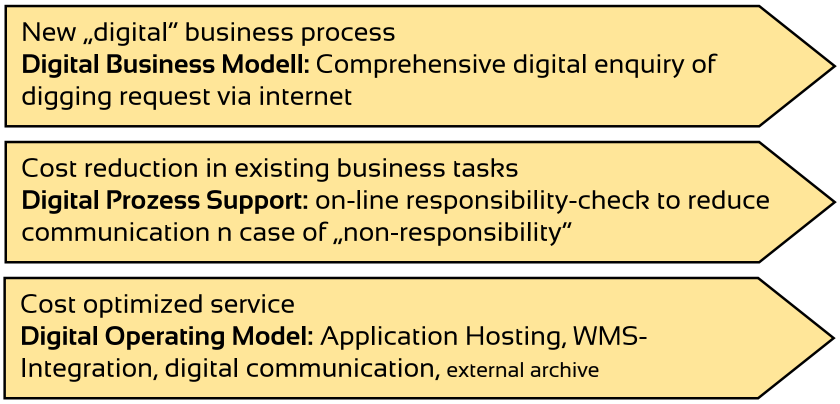

Illustration 6: Digital business process support for energy industry

In the age of industrial digitisation, BIL can also help to boost the efficiency of processes that need to be optimised due to increasing construction activity, a decreasing headcount and standardised options for response. Individual operators developing their own planning information portals is a step in the right direction; it requires, however, that enquirers know which operators to address in the first place.

BIL wants to solve this problem and pass on the enquiry information to the systems of the relevant operator(s).

OBJECTIVE AND OUTLOOK

It is BIL's ambitious goal to become "the go-to portal" for pipeline/cable information from operators of all sectors. The main motivational factor is to simplify the mandatory enquiry process for the construction industry with the aim of providing "complete" information.

The enquiries are free of charge for private individuals, building contractors or operating companies. Implementation, maintenance and expansion of the system will be carried out by the BIL organisation in collaboration with third-party service providers and thus only requires a small set-up. Therefore, the foundation of a registered cooperative was identified as the most suitable organisational structure. This way, operators of all types of pipelines and media may participate on a not-for-profit basis. Based on the experience of operators of critical media, initial implementation was carried out which fully covers the requirements for web-based building enquiries. In addition to transmission system operators, BIL wants to reach the operators of local distribution system infrastructures, in particular municipal utilities and telecommunication companies, but also operators of biogas pipelines or other media.

The spanfield analysis between high voltage transmission grid operators and the pipeline industry to optimize operations in the energy change debate demonstrates the benefits of a registered cooperative to solve economic demands.

> *With 1 million construction sites in Germany each year and figures rising, the construction industry is in need of information on pipelines and cables and their routes both underground and aboveground. A simplified inquiry process an contribute to safety and effectiveness.*
>
> Jens Focke

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Prof. Dr. Jürgen Schmidt, Natalie Schmidt, Johannes Biernath > CSE Center of Safety Excellence

PIPELINE SECURITY

PUBLIC AWARENESS AND MITIGATION OF THIRD PARTY ACCIDENTS AS NEW LAYER OF PROTECTION FOR THE CRITICAL INFRASTRUCTURE GAS

ABSTRACT

Gas transmission pipelines belong to the critical infrastructure – they are essential for the energy supply of the industry and public households. International and national statistics[1,2] show a continuous decrease in the number of events per 1000 km pipeline length as a result of a permanent increase in Technical Safety during the last thirty years. Nevertheless, catastrophic incidents like gas explosions in Ghislenghien[3], Gräveneck[4] or Oppau[5] can't be fully excluded. Third party activities, especially through excavators and drilling machines, are the main the reason for these incidents. The most effective topic to further enhance the current safety standard of gas transmission pipelines is the protection of the critical gas infrastructure from external impacts. Especially in Germany population density locally increases while public acceptance of incidents decreases continuously. An innovative pipeline security concept is needed - it is time for a paradigm shift: pipelines shall additionally be protected by (1) a **Th**ird party **an**ti-**c**ollision **s**ystem (THANCS) based on latest Industry 4.0 opportunities and (2) an active role of the population to ensure pipeline security. As a consequence, the **Eu**ropean **Ri**sk **C**ommunication Platform (EURIC) is founded at the CSE Center of Safety Excellence to deepen the research in this field.

"Gas transmission pipelines belong to the critical infrastructure – they are essential for the energy supply. Statistics show a continuous decrease in the number of incidents per 1000 km pipeline length as a result of a permanent increase in technical safety in the last thirty years. Especially in Germany population density increases while public acceptance of incidents decreases continuously.

Prof. Dr. Jürgen Schmidt

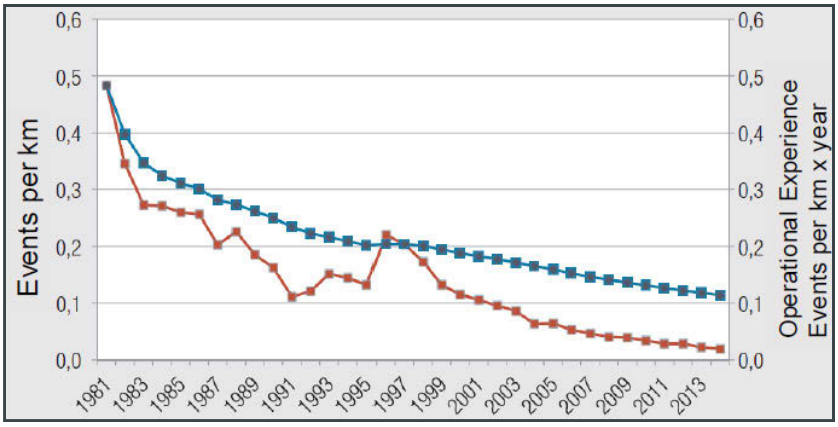

Figure 1: Event frequency per km in the German gas transmission network between 1981 and 2014 according to statistics of DVGW

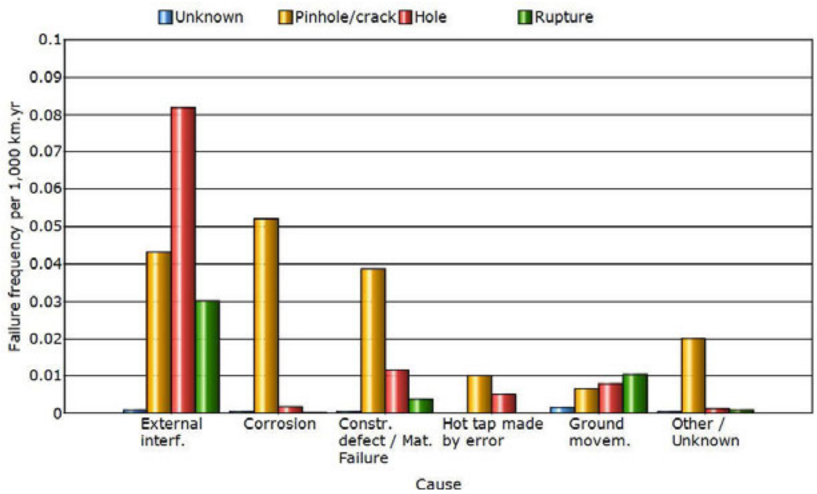

Figure 2: Frequency of incidents in registered pipelines due to EGIG13

INTRODUCTION AND STATE OF THE ART

The gas network extends to over 510,000 km[6] within Germany and ensures the public and industrial energy supply.

According to the German Energy Industry Act (Energiewirtschaftsgesetz)[7], the security of the energy supply and the Technical Safety of these pipelines must be ensured. Technical Safety was significantly increased over the last decade in the areas of corrosion protection, pipeline construction, monitoring and in-line inspection systems. As a result, international and national statistics show a continuous decrease in the event frequency per km[8,9],see Figure 1.

Although Technical Safety is significantly enhanced, still major catastrophic incidents such as in Ghislenghien (2004)[10], Gräveneck (2007)[11] and Oppau (2014)[12] occur. The risk for these incidents is very low, but they cannot be fully excluded.

The main reasons for such events are external interferences, in particular by excavators, drills, as well as agricultural and forestry equipment, according to the data of EGIG (European gas pipeline incident data group, a consortium of the 17 major European gas pipelines operators), Figure 2.

The probability of incidents to occur due to construction activities in distribution and house service connections is much higher than in long distance gas transmission pipelines. In contrast, impacts with damage to property and personal injury are usually low. An extract of various incidents during the last months is summarized in Table 1.

Date	Location	Incident
08/05/2016	Alheim	Rupture of a gas transmission pipeline by an excavator[14]
30/05/2016	Cham	Rupture of a gas transmission pipeline by an excavator[15]
22/06/2016	Bad Wiessee	Damage of a gas transmission pipeline by an excavator[16]
14/07/2016	Eltville-Hattenheim	Cut off of a gas transmission pipeline by an excavator[17]
11/08/2016	Wunsiedel	Damage of a gas transmission pipeline by an excavator[18]
25/08/2016	Wiesbaden-Erbenheim	Construction worker gets seriously injured by a jet flame caused by an accident at a gas transmission pipeline[19]
16/09/2016	Hetter-scheidt	Rupture of a gas transmission pipeline by an excavator[20]
26/09/2016	Ahrensburg	Damage of a gas transmission pipeline on a construction area[21]

Table 1: Non-representative list of open source publications of external interferences on gas distribution lines by excavators in Germany within 5 month of 2016

If the pipeline is damaged, combustible and explosive gas is released. A small spark can cause an ignition and an explosion due to, for example, the contact between the pipeline metal and the excavator bucket. The damages can be particularly devastating, if the gas has been distributed in the buildings before the explosion takes place, Figure 3, especially in areas with high population density.

> *"Despite preventing measures, with about 1 million construction activities annually in Germany, accidental events on gas pipelines can only hardly be avoided. About 80 % of the damage on pipelines are human errors due to work with machinery.*
>
> *Prof. Dr. Jürgen Schmidt*

The German Technical and Scientific Association for Gas and Water (DVGW) has defined a very high safety standard to ensure the Technical Safety of pipelines during planning, construction and operation and, hence, to protect people and the environment against potential hazards of the pipeline. In addition, a protection of the pipeline from external interferences on the same safety level is needed.

This is challenging, because Technical Safety measures are lacking. Worldwide, organizational measures to prevent an incident due to third party activities are standard. In Germany, Technical Safety measures for construction and earthwork are regulated in many codes such as DVGW GW462-1, GW315 und GW381, TV A-StB 12 worksheets or also BGI 759 as organizational measures. Prior to any earthwork precise local maps of the pipeline network need to be requested, pipe network operators must be identified and in case the excavation work takes place in the vicinity of pipelines, workers often need to prevent a collision by means of carefully shoveling, before the roundup will continue.

Despite these measures, with about 1 million construction activities annually in Germany, accidental events on gas pipelines can only hardly be avoided. About 80% of the damage on pipelines are "human errors" due to work with machinery[22]. Training, strengthening of a safety culture, additional technical measures and public awareness are the main driver towards a higher level of security for gas pipelines. BALSIBAU for example is an initiative of the DVGW to increase the training standard of excavator drivers and drilling operator. Unfortunately, the training is not yet mandatory.

Figure 3: major catastrophic event in Itzehoe (Germany) 2014 through an explosion of a gas distribution line caused by a third-party intervention Source: dpa

Another major step to enhance the prevention of accidents is a central system for construction applications – an interface between construction industry and pipe network operator. In 2015 several pipe network operator have founded BIL as an information platform for critical infrastructure in Germany. BIL is an important prevention measure and may further be integrated into a pipeline security concept. Industry 4.0 opens the opportunity for a link between construction machines and gas network maps.

Renewable Energy is very popular in Germany and seem to be available limitless and with less potential hazards compared to natural gas. For a major part of the German society the need for natural gas is not obligatory. Any incident and especially a catastrophic incident may strengthen the public demand to further increase the security of natural gas pipelines. Hence, a continuous improvement of the existing Technical Safety concept for gas pipelines by means of adaptation to the current State of Safety Technology is necessary. In addition, the quality of pipeline security measures to protect against an external interference need to be increased.

PIPESECURE2020 – NEW LAYER OF PROTECTION FOR PIPELINE SECURITY

The CSE Center of Safety Excellence initiated the "THANCS" program (Third party Anti-Collision System) with the intention to combine latest navigation and detection technologies for a development of a new excavator anti-collision system to avoid third party incidents.

In addition, an innovative communication concept should encourage the motivation of the general public to secure actively the protection of pipelines. Based on the Nudging-Principle, people's behavior should be altered in a predictable way without prohibitions, instructions or significant changes in economic incentives[23]. Present types of communication are used mostly for an information transfer to strengthen the public perception of safety, but do not encourage the public awareness.

To introduce a new awareness and mitigation concept, latest findings of risk acceptance and communication shall be applied to parties living within a zone of potential consequences of natural gas pipelines. Risk shall be understood, accepted as part of a life, but no fear shall be inspired. In many cases, engineering and objective argumentations, which are dominated by numbers, are insufficient to encourage the necessary trust in the communication. The situational circumstances of those communications have to be suited to the typical application procedure (heuristics) of nontechnical people.

The development of new layer of protection in a security concept for the gas infrastructure to protect pipelines from external interferences is the aim of the project "PipeSecure2020" at the CSE Center of Safety Excellence. The CSE-Institute is a non-profit competence center for research and education in the field of process and plant safety.

The center is guided by an industrial advisory board in the areas of chemicals, petrochemicals, oil and gas and has special knowledge and decades of experience in handling and protecting risks of technical plants. The partner of the CSE Institute - the CSE-Society: Society for the Promotion of the Process and Plant Safety e.V. – includes about 40 renowned companies and institutions. Among others, BASF, Bayer, Linde, Siemens, Gasunie Germany, Thyssengas and Open Grid Europe as well as the German Technical and Scientific Association for Gas and Water DVGW, but also many small and medium-sized enterprises, universities and worldwide partners.

The CSE-Institute´s mission is to develop innovative safety concepts in order to increase the global and cross-industry safety of critical infrastructures. An industrial-scale testing installation to perform flow measurements and type testing of safety device with pressures up to 3400 bar (~ 50 000 psi) is under construction, Figure 4. The facility is built in co-operation with the Fraunhofer Institute for Chemical Technology in Pfinztal near Karlsruhe, Germany.

Research is embedded in an interdisciplinary education of young academics in the field of process and plant safety at Karlsruhe Institute of Technology, the Technical University of Kaiserslautern and the University of Applied Science in Karlsruhe. Directors of the CSE-Institute are Prof. Dr. Jürgen Schmidt and Prof. Dr. Jens Denecke with more than 35 years of experience in protection of technical plant, especially chemical and petrochemical plants.

Figure 4: CSE High pressure loop for flow measurements and type testing at pressures up to 3400 bar (~50 000 psia)

THANCS PROGRAM

The CSE-Institute aims to develop an innovative alarm system to automatically warn the operator of an excavating machine when approaching a gas pipeline and switches off the construction or agricultural machinery before an actual contact happens. On the one side, this Technical Security measures increase the protection of gas pipelines for the construction industry. On the other side, potentially affected persons in the vicinity of gas pipelines are also better protected.

As a first easy and inexpensive preventive security measure, a warning system embedded in a mobile device is planned. Machine operators of excavators and drilling machines will be warned of a potential damage to gas pipelines optically and acoustically from their mobile device. Gas network operators will be identified and informed about the actual risk situation evaluated on the basis of e.g. the population density in the surrounding of the pipeline. To enable the availability in rural areas (gaps in the mobile device network) or urban building situations, in a subsequent step this alarm system will be enhanced to a local autonomous system.

An appropriate detection system for gas pipelines must be found in addition to the mobile device warning system. Measuring systems from other branches like the archeology and the measuring principle of the geomagnetism offer a good source base for that purpose. On the basis of the autonomous alarm system, a prototype of an automatic anti-collision system in a construction machine that switches off the machine before a contact with a gas pipeline happens (Industry 4.0 Device) can be developed.

For the conversion of these Technical Security measures precise geodata are necessary for the spatial position of all pipelines. Present offers for pipeline network information like the nationwide management system of pipeline net data information (BIL) are currently based on available two-dimensional geographical data. These data are received from responsible gas net operators with a certain degree of incompleteness and exactness, for instance, of the depth of a pipeline.

The European guideline INfrastructure for SPatial InfoRmation in Europe (INSPIRE) may lead on a long term basis to more precise electronically available data of critical infrastructures but may involve further potential security weak points. The digitization and the comparison of data from the information of gas net operators and public sources is a challenge within the project. Suitable measuring methods, for instance, GPS detection or ultrasonic measurements, must be further optimized to allow the integration of these data from inspection devices.

EURIC: EUROPEAN RISK COMMUNICATION PLATFORM

A comprehensive protection from external interferences on gas pipelines may be attained if in addition to the construction industry the society or at least potentially affected people are integrated. This new concept of protection does not yet exist in any European country, neither in Germany nor in another European land. The population will be involved actively into the protection of critical infrastructure and promote the awareness in public. Analogous to the behavioral employment protection in companies that demand a personal responsibility of their employees for their own safety, the CSE Center of Safety Excellence aims to develop a suitable communication concept and public education program.

For this purpose, the risk perception of the population has to be examined regarding the hazards of the critical infrastructure. The risk perception and acceptance of the population shall be investigated for different risk-based and deterministic concepts of Technical Safety. On this basis, the behavioral pattern of the population in present public information events, can be directed. Risks have to be appointed openly and target-audience-oriented, civil reliance has to be built and converted into a positive attention.

To date, the public discussion on technical risks, for example, in project approval procedures, is mostly only based on a mediation of information that strengthens the security feeling of the citizens, indeed, but does not promote general attention in the public. Potential hazards are often not addressed but faded-out. The high level of Technical Safety may lead to an "emotion of zero-risk" in the society with the consequence of zero awareness even to obviously risky situations. Instead of acting towards hazard mitigation or following an escape reflex a minority of the society tend to fully fade-out hazardous situations. Hence, an innovative communication draft should be compiled outgoing by current citizen's information and integrated in new media and topical results of risk perception. For this, qualitative customer surveys will be carried out on the basis of morphological effects and communication research.

A major aspect is to develop a communication strategy. The aim of the new communication strategy is to train people's awareness on risks and to motivate them to report potential hazards to a central information system. In this context, the term mindfulness of the public means to understand, detect and report potential hazards or abnormalities in construction areas. This concept is based on the Nudging Principle and should influence the civil behavior without giving orders or imposing bans. For this, it is essential that a respectable trust base is created between the population and the gas net operator or a third party (e.g., the CSE Center of Safety Excellence).

The strategy should motivate the population to announce potential hazards to a central information system from their point of view, which initiates safety relevant measures according to a risk judgement and informs gas net operators and authorities if necessary. The situational circumstances of those communications must be suited to the typical application procedure (heuristics) of nontechnical people.

At the same time, an assessment matrix for the classification of the hazard potential, which is based on simple, automated risk assessment methods, should be developed. In this way, measures can be defined in a catalog, which may be activated depending on the respective hazard message. Thereby, a determination of the necessary information for the evaluation of potential hazards is essential.

SUMMARY

The CSE Center of Safety Excellence initiates the PipeSecure2020 program with the objective to improve the security of the critical infrastructure gas by protecting the pipeline from external interferences. This should be done (1) by an innovative alarm system for machine operators of excavators and drilling machines and by a further development to an automatic anti-collision system for such devices. For that, precise local geo-data of gas pipelines are needed. The development of (2) risk-based communication measures has the aim of encouraging not only machine operators, but also the population according to the principle of Nudging, so that any impermissible approach to a gas pipeline is preventively avoided. The new program aim to result in a comprehensive new protection approach to pipeline security for critical gas infrastructure.

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APPLICATION OF PROACTIVE RISK MANAGEMENT IN PIPELINE INTEGRITY

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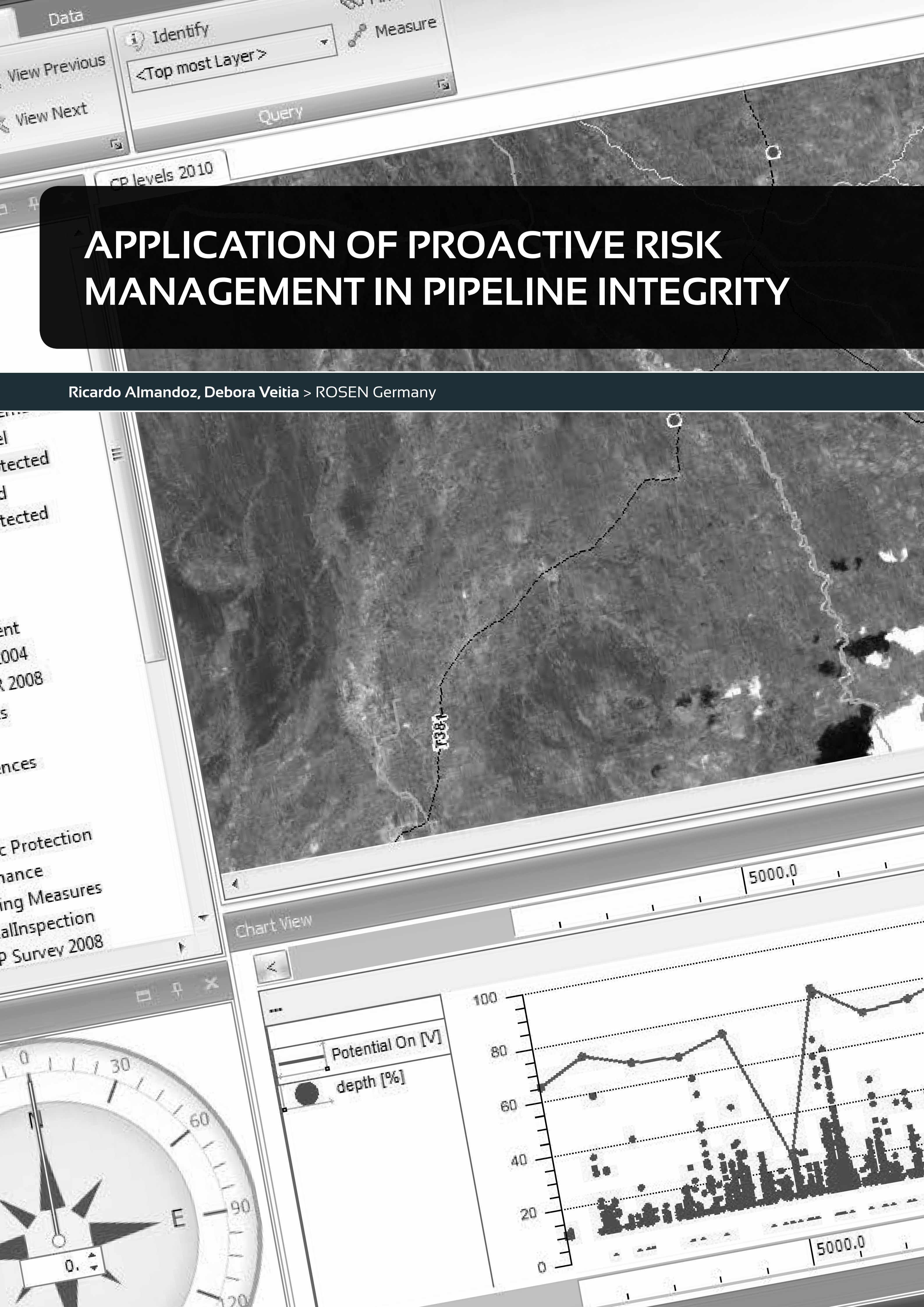


ABSTRACT

Risk management is an essential element in the pipeline integrity management process. Risk management involves not only the estimation of risk profiles and comparison against tolerable criterion but also ensuring that measures to treat the risk are effectively assessed and implemented. Performing risk assessments can assist operators and engineers in understanding critical issues such as:

- which threats are more likely to endanger the pipeline's integrity,
- which areas of the pipeline are more susceptible to failure from the active threats, and
- if failure occurs, how is the released product likely to be dispersed and possibly affect critical receptors.

If risk is managed proactively rather than reactively, operators should be able to apply preventative and mitigative measures early enough to prevent pipeline failure from occurring. In addition, adopting a proactive/preventative strategy would allow resources to be effectively utilized for the optimization of maintenance plans. Enabling such assessments requires an effective risk model, hence efforts are focused on modelling and estimating the risk of pipeline failure in a quantitative manner. Such models can be highly complex, detailed, and require large amounts of data integration; in addition, they need to generate risk factors in a consistent and transparent manner to support effective decision making.

ROSEN's Quantitative Pipeline Risk Assessment Model (QPRAM) was developed to address the expectations and challenges inherent in identifying and assessing risk factors. QPRAM incorporates probability, consequence, and risk elements into a modular framework, and allows flexible construction of customized models to reflect specific applications such as pipeline location, fluid type, data availability and required level of complexity.

This paper describes how the QPRAM methodology was developed and implemented in collaboration with a European gas pipeline operator. A customized risk model was constructed together with the operator to reflect bespoke conditions and challenges associated with the operating environment, known threats, and data availability and quality. The model provides essential risk factors at high-resolution intervals along their lines, and was calibrated using real data to ensure that the resulting risk profiles are reflective of the threats and operating experience in their region.

The integration of pipeline data and the implementation of QPRAM is managed in ROSEN's Asset Integrity Management Software (ROAIMS) suite. This enables the operator to identify and compare the risk of pipelines in their network, identify active threats to any pipeline, focus on areas with elevated risk, and assess the benefits of preventative mitigation measures. Managing data and assessments in a suite provides the added benefits of consistency and traceability.

Upon completion of risk assessments, proposed preventative and mitigative measures are analyzed together with other integrity assessments such as fitness-for-purpose assessments to provide an overall integrity management plan that provides guidance to the operators on what should be done, where and when, to ensure the pipeline's integrity is proactively managed.

> *"If risk is managed proactively rather than reactively, operators should be able to apply preventive and mitigate measures early enough to prevent pipeline failure from occurring. In addition, adopting a proactive / preventive strategy would allow resources to be effectively utilized for the optimization of maintenance plans.*
> Ricardo Almandoz

INTRODUCTION

RISK MANAGEMENT DESCRIPTION

Risk management is an essential element in the pipeline integrity management process. Risk management involves estimation of risk profiles, comparison of the results against tolerable criteria and ensuring measures to treat the risk are effectively assessed and implemented.

Often, risk is evaluated up to the 'assessment' stage i.e. efforts are focused on defining models, processing data for executing analyses to generate probability, consequence and risk factors, and then comparing the results with acceptability thresholds, or simply generating risk metrics to visualize the results. Identifying areas of interest is clearly not enough to prevent assets from failing, therefore the 'management' aspect involves assessing and implementing effective preventative & mitigative (P&M) measures to treat and control the risk.

Risk assessment is an essential step in the process of supporting operators with proactive decision making. Identifying points or areas of interest along the pipeline asset not only provides an awareness of the likelihood of failure or degradation due to credible drivers at specific locations, as well as the potential elevated impacts to receptors in the case of failure, but more importantly assists in determining when and where to apply P&M measures. However, reaching this stage relies heavily on meaningful assessment results, which are often challenging to achieve.

Various fundamental aspects must be properly addressed in order to reach the milestone of being able to effectively manage risk. These include:

Enabling an effective strategy: The risk approach should meet key principles (e.g. should be an integral element of the IM process, should assist with decision making, should be systematic and continuous, transparent and consistent), have a framework for implementation, be well communicated, and continuously executed and monitored. The ISO 31000 [Ref.1] standard provides generic guidelines on the principles, framework and process that could be applied for risk management. Other pipeline-specific guidelines such as ASME B31.8S [Ref. 2], IGEM TD/2 [Ref. 3] or DNV RP F116 [Ref. 4] provide recommendations for managing integrity and risk. Operators often reference these guidelines while producing their individual corporate frameworks. An effective strategy should facilitate continual improvement and enhancement of risk management within an organization.

Defining an effective risk model: There are documented and known risk model classes, ranging from simple 'qualitative' models depending largely on subject matter, expert judgement, and producing risk results in relative terms, to more complex 'quantitative' models that require large quantities of numeric input data, remove subjectivity, and yield results in absolute terms. To assess risk, an effective risk model and structure is required in order to estimate the risk factor results. The risk model is a set of structured rules (algorithms) that use available information and data relationships to estimate the performance of the system from a risk perspective.

Although there are several guideline documents addressing risk assessments of pipelines, such as ASME B31.8S [Ref. 2] for onshore gas transmission pipelines or DNV RP F116 [Ref. 4] for offshore pipelines, there is no industry standard for defining uniformity among risk models. As such, models developed and applied in the industry vary considerably in their complexity, structure, effectiveness and usability. There is an art and a skill to finding a balance between factors such data availability, complexity, integrating subjectivity and absolute information, tailoring models to meet bespoke conditions, and result transparency, consistency and interpretability when defining effective models.

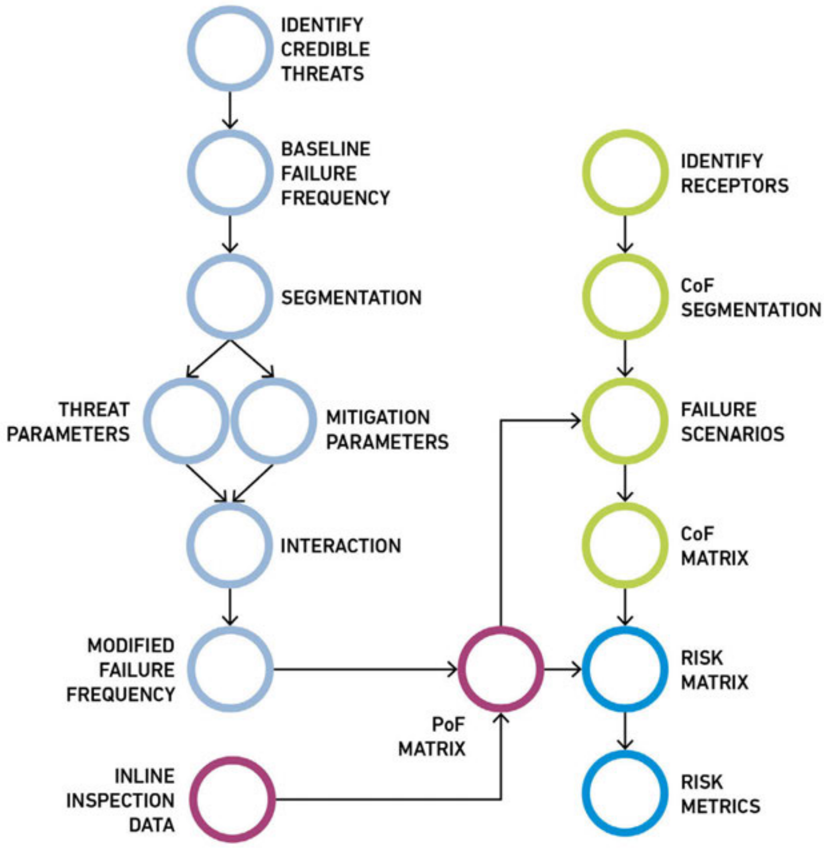
Gathering and integrating effective data: Having a model alone does not produce risk results; a risk model is basically a placeholder, and only when data is introduced are profiles of the risk factors generated. Managing data can have several associated challenges, including but not limited to access and editing by multiple users, availability, quality and security, inconsistency with formats and database structures, processing, alignment and integration into a centralized repository, onerous and increasing data volume, and resource availability. As expressed in the point above, data availability and accuracy is an important influencing factor for tailoring risk models; sometimes adopting a phased approach to updating and fine-tuning models relative to data availability is recommended. Data is usually reflective of a snapshot in time, therefore it is important to continuously gather, process and integrate data to assess risk throughout the asset's lifecycle. Availability, accuracy and integration of data in a timely and consistent manner is also critical for yielding meaningful risk results.

Generating meaningful, interpretable & consistent results: The pipeline industry is tending to more semi-quantitative and quantitative risk approaches that require objective measures of probability, consequence and risk factors. Results yielded from analyses should therefore be quantifiable, measurable and comparable. Analyses can return extensive results, however expressing metrics in a way that optimally supports decision making is important. Using combined views of matrixes, charts, tables, and maps assists with visualizing, assessing, understanding, and communicating results, as well as planning treatment activities. Transparency and consistency of results, and the ability to assess different levels of detail, from overview profiles to root causes, are also necessary. Results produced from an analysis are usually compared with tolerable criterion to identify and differentiate areas that exceed acceptable thresholds and therefore require treatment.

Performing sensitivity analyses: Upon identifying areas of interest from the assessment stage, various feasible P&M measures should be assessed to control and reduce the risk to within a tolerable level. This is often supported by a carrying out a combination of what-if sensitivity and cost-benefit analyses. These measures are barriers that if effectively applied could reduce the pipeline's likelihood of degradation and even failure; these include a combination of treatment, maintenance, inspection, surveying, assessment, repair/rehabilitation and quality assurance activities. Obtaining a practicable balance between cost, gain, loss, and timing of P&M measures is required, although potentially challenging.

QPRAM METHODOLOGY

ROSEN's Quantitative Pipeline Risk Assessment Model (QPRAM) was developed to address expectations and challenges with identifying and assessing risk factors. Although pipeline risk and integrity management is a global challenge, the issues faced can be very local and individual. Therefore, having the flexibility to tailor the risk model to address bespoke conditions and challenges associated with the operating environment, known threats, data availability, and quality is important.



The QPRAM workflow contains modular elements which aid in estimating risk factors

QPRAM incorporates probability, consequence and risk elements into a modular framework and allows flexibility in constructing customized models to reflect specific applications such as pipeline location, fluid type, data availability, subject matter expert input, and required level of complexity.

THREAT ANALYSIS

QPRAM provides a common framework for evaluating the likelihood of failure due to credible threats by assessing the historic failure frequency of the pipeline system with a combination of mechanistic, operational and environmental conditions. The model assesses the severity of conditions that could affect the pipeline's integrity degradation, and compares the severity against the quality and effectiveness of passive and active preventative and mitigative measures.

Historic failure frequency is a fundamental input to the model and should ideally reflect expected local conditions; however if this data is not available, regional or national statistics could be used. The severity of the driving mechanistic, operational and environmental conditions, combined with the quality and effectiveness of preventative and mitigative measures, produce a ratio that is then applied to the historic failure frequency to generate a modified failure frequency profile along the pipeline. When the mechanistic, operational and environmental conditions and the preventative and mitigative measures vary along the pipeline, a new dynamic segmentation is produced.

Inspection data (such as from an intelligent inline inspection) and associated assessments (such as fitness for service) provide relatively accurate information regarding presence, size, and criticality of anomalies in the pipeline, which in turn can be used to infer the presence and severity of the active threat in the line. This data (if available and relevant) is then compared with the modified failure frequency to generate a refined failure frequency profile along the pipeline.

The result is a highly detailed profile of the modified (or refined) failure frequency values showing the variation relative to historic frequency. Thus, areas of the pipeline are identified that are more or less likely to fail than average (baseline) and by how much.

CONSEQUENCE ANALYSIS

The aim of the consequence analysis is to estimate the relative impact to receptors in close proximity to and along the pipeline should the pipeline fail. To this end, QPRAM utilizes a common 4-stage process:

1. **Characterize the most likely failure scenarios**: If a pipeline fails due to a specific credible threat, the failure mode likelihood (leak vs full bore rupture) is assessed. Upon release of the product in the environment, varying credible failure scenarios are evaluated, leading to the development of an event tree. Common simplified scenarios are rupture of the pipeline followed by immediate ignition of the product, resulting in jet fire, or leak of the pipeline followed by no ignition.
2. **Calculate the hazard zone**: Depending on the scenario being assessed, the impact could affect a zone relative to the failure point along the pipeline. For example, the scenario of a rupture of the pipeline followed by immediate ignition of the product resulting in a jet fire produces thermal radiation, and the intensity of this radiation at varying distances from the fire could be determined using a point source method [Ref. 5]. By considering tolerable thermal radiation intensity thresholds, associated impact radii could be calculated to determine hazard zone areas.

3. **Identify receptors likely to be affected**: Receptors such as people, environment and infrastructure that could be affected by the failure are identified. The pipeline and surrounding receptors are constructed within a Geographical Information Systems (GIS) environment, and detailed spatial queries are executed at regular intervals along the pipeline to identify where receptors could be affected within the hazard zone of a potential failure scenario.
4. **Estimate the potential damage to affected receptors**: The severity of the impact to the receptors from the respective scenario is estimated both separately and holistically using a common metric. This could be measured for example in cost-specific terms, expected fatality, or interruption of supply. Not only the impact to physical receptors within the hazard zone is estimated, but also economic impacts (including loss of product & production, and repair and recommissioning costs), as well as less tangible impacts such as company image (including confidence, share price, etc.) are assessed.

RISK ASSESSMENT

Risk of failure is the product of probability of failure results (from the threat analysis) and the consequences of failure results (from the consequence analysis). Probability, consequence, and risk values can be mapped to categorizations and compared on metrics such as corporate risk matrices. Additional risk metrics such as distance-based profiles of the risk value could be generated, showing the total risk or comparing the risk among the credible threats; such profiles highlight points or areas of interest. Risk factor profiles could also be visualized on a map view to associate segments with elevated probability, consequence or risk with spatial data sets such as populated areas, infrastructural density or environmental hotspots.

IMP DESCRIPTION

The Integrity Management Plan (IMP) is developed to set out the requirements for future inspection, monitoring and maintenance activities to control and mitigate credi-

Section	Length (km)	Construction date (year)	Diameter (inch)	Wall thickness (mm)	Pipe Material	Design Pressure (MPa)	MAOP (MPa)
1	45	1972–1973	28	6.5/7.92/10.31	X60 X60C	5.4	4.8
2	80	1973–1974	28	6.5/7.92/10.31	X60 X60C	5.4	5.4

Table 1: Pipeline characteristics

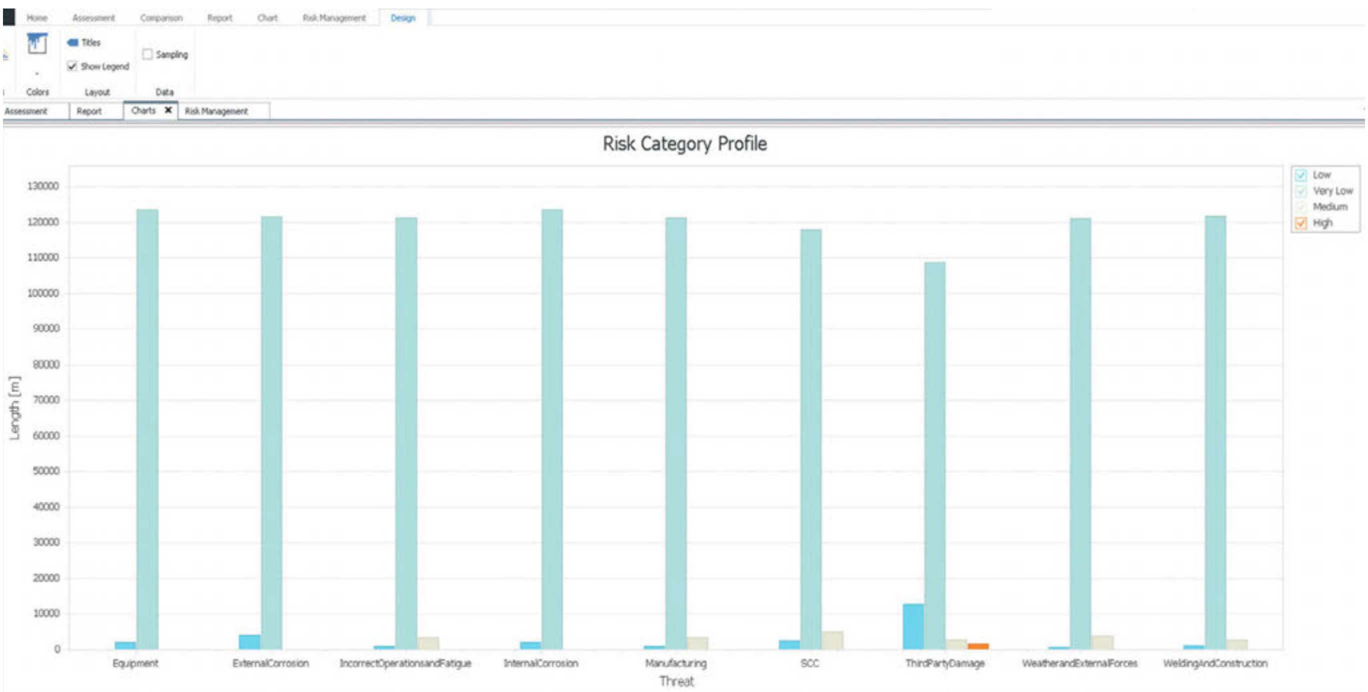


Figure 1: RA Results: Risk category profile

ble integrity threats and risk. The plan compares historical activities to the latest risk and integrity related assessments to determine the appropriateness and frequency of future activities. Examples of integrity-related assessments which could be integrated into an IMP include fitness-for-purpose assessments and risk assessments.

The proposed activities and frequencies outlined in an IMP should support product transmission under safe and reliable conditions. Risk Assessment and IMP should be regularly reviewed to ensure that credible threats are being properly managed. Changes to the operation of a pipeline or surrounding environment should trigger a review or re-assessment.

In addition to the generation of an action plan, key performance indicators should be set to measure the effectiveness of the plan and subsequent activities. Examples of these performance metrics include:

- Say/do ratio (activities planned vs activities completed during the measurement period)
- Maintenance effectiveness (planned maintenance hours vs unplanned maintenance hours)
- Risk reduction (difference between the risk from the start to the end of the measurement period)
- Non-compliance tasks (number of reported vs non-compliance tasks in the measurement period)
- Repair Reduction (number of planned repairs following the next inline inspection vs the current plan)

CASE STUDY

The QPRAM methodology was applied in a gas pipeline; characteristics are shown in Table 1.

There have been four identified failures in this pipeline, two of which were attributable to stress corrosion cracking. The primary impact was product loss. The data required for risk assessment includes inline inspection, above ground-surveys, gas composition, and operational parameters. The consequence model expresses the potential consequence of failure in terms of cost (BLV). These values are dependent upon local factors such as labor and material costs. The results of the threat and consequence analyses were combined to calculate the risk along the pipeline and highlight those areas where the risk is higher so that recommendations could be generated to reduce the risk to acceptable levels.

The risk results are displayed in Figure 1.

When the results are expressed in terms of probability and cost (per event), the risk value is an expression of the liability i.e. the average cost of failure per year. The stacked PoF, CoF and Risk Profiles are displayed in Figure 2.

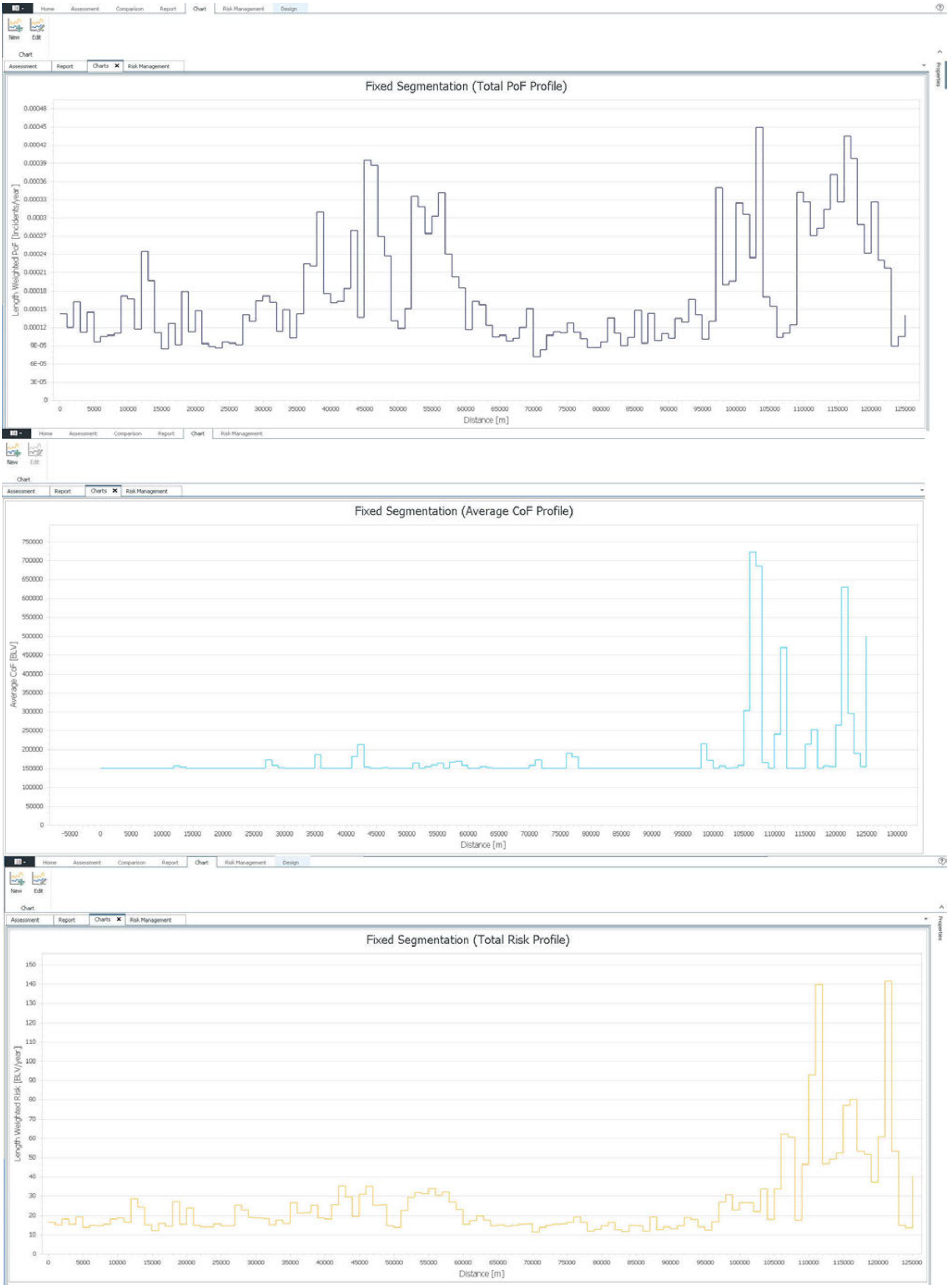


Figure 2: RA Results: PoF, CoF & Risk profiles

As can be noticed, the highest risk value (~142 BLV/year) occurs at ~121000 m, where the section is adjacent to one of the more populated areas, including roads, and also has a relatively high likelihood of failure. An alternative way of viewing the risk results is cumulatively, as displayed in Figure 3.

The cumulative risk for the pipeline was 3,245 BLV/year. While the risk is fairly uniform along the length of the pipeline, with small peaks at populated locations, this chart shows that almost half the risk cumulates in the final 25 km (~1/5) of the pipeline. Any risk reduction measures deployed in this section would have a significant effect on the overall risk. In cumulative terms, it is the risk of third-party damage in the final 25 km that is of primary significance here.

The main aim of the operator is to focus efforts on reducing failure frequency and preventing failure, since there are limited activities possible that could reduce the consequences. Operators therefore need to identify which threats increase the risk of failure, and define a strategy to mitigate them.

Figure 4 below provides a comparative distance-based view of the risk profiles of the threats. As can be seen, third-party damage (TPD) is the most critical threat for this line; it clearly yields the higher PoF profiles. Thus it makes sense to prioritize resources to mitigate this threat. For the case in question, the focus will be on assessing the risk from TPD.

Once the main drivers for the primary threat are identified, sensitivity analyses can be performed to define a maintenance plan to treat the elevated risk. It is important to mention that before applying corrective or preventive actions, a quality check of the data used for the assessment must be executed. Additional data collection or review could also be required to reduce any uncertainty that might exist regarding the analysis.

The Driver Mitigation Ratio (DMR) charts provide a good indication of the root causes/leading factors that increase susceptibility, which is helpful in determining where to invest the resources. Figure 5 illustrates the profile of the DMR along the line for each driver of TPD.

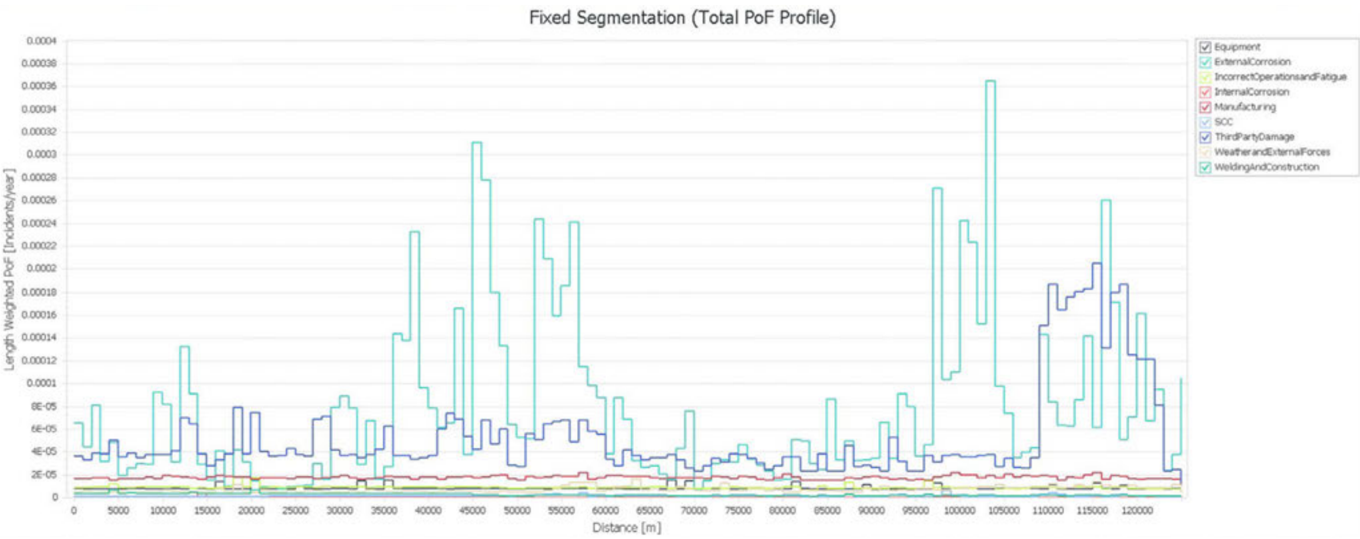


Figure 4: RA Results: Fixed Segmentation (Total PoF profile)

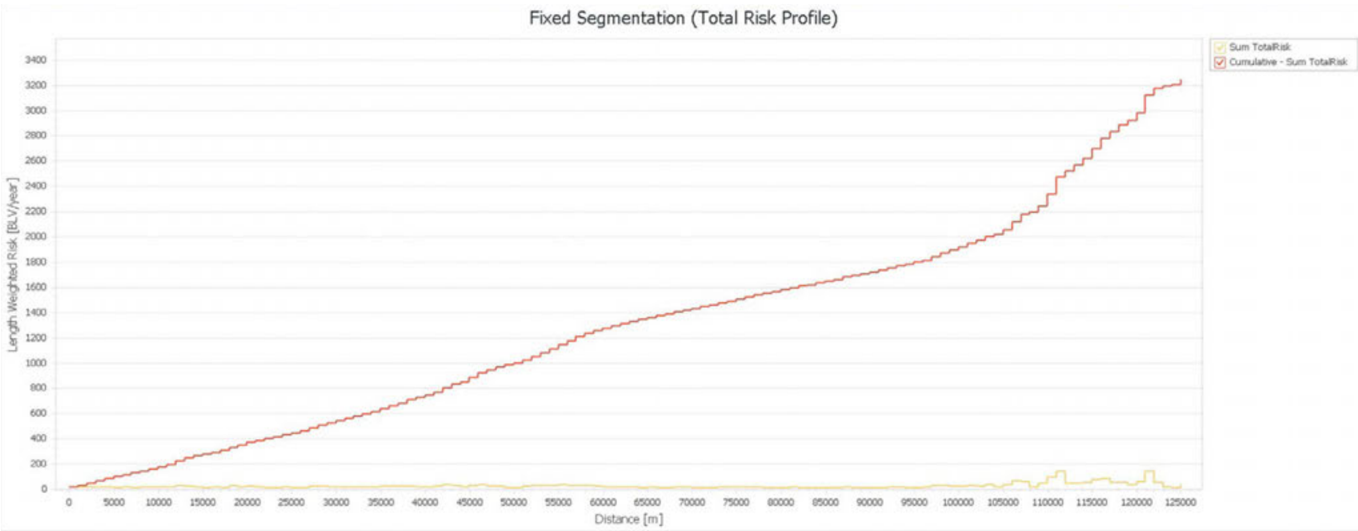


Figure 3: RA Results: Risk Profile and Cumulative Risk

Figure 5 shows the drivers for TPD that vary the most along the line, which are pipe disposition, population near ROW, parallel pipelines in ROW (same operator) and areas susceptible to external interference in ROW. One recommendation to consider for reducing this effect is to increase patrolling of the last 25 km of the line to twice per year, especially because this is an influential area where considerable consequences would be likely to arise from third party damage. Another recommendation might be to inform the local population and landowners, perhaps with the support of the public education system and to ensure the effectiveness of the public education system.

IMP

As mentioned before, IMP compares historical activities to the latest risk- and integrity-related assessments to determine the maintenance plan. For the case in question, data from fitness-for-purpose assessments, records of inspection, and monitoring and maintenance frequencies were also taken into consideration.

Considering TPD as the most critical threat in this case, some important findings from the overall review should be mentioned:

- The pipeline route is predominantly rural with a small proximity to villages (~15%).
- The nominal burial depth is 0.9 m and the line is buried for its length with the exception of 3 aboveground crossings. These locations are noted as having an increased wall thickness of 10.31 mm as mitigation against impact.
- One dent was not reported by the ILI due to being outside the detection capacity of the inspection tool. The defect is considered top of line and was identified as possible gouging, and may therefore be due to third-party damage. This defect was initially discovered in 2013, after which the section was recoated.
- A procedure for regularly informing landowners of the presence of the pipeline and potential dangers of causing damage does not exist. There is a legislative requirement to maintain a 200 m right of way in respect to high pressure gas pipelines. Surveillance of this area is carried out at fixed intervals (annually) but the survey frequency does not take population density into account.

Based on the analysis performed, some recommendations could be considered to support the continued safe, reliable and environmentally responsible operation of the pipeline, such as:

- A third-party damage prevention program should be developed, including landowner and public liaison. Following its implementation, the effectiveness of the program should be subject to regular review.
- Surveillance activities should be planned and executed using a risk-based approach that prioritizes high-consequence areas. Generally speaking, these areas cover the final 25 km of the pipeline.
- Regarding the single top-of-line dent, previous recommendations should be reviewed to ensure they were completed. If no recommendations or actions were completed, the following should be carried out:
    - Consult records (e.g. surveillance reports, land access records, etc.) to determine if the dent is located in an area at risk for third-party damage.
    - If the dent is located in an area at high risk for third party damage, execute a local aboveground survey at the location of the dent to determine if there is associated coating damage.
    - If the dent has associated coating damage, it should be excavated to determine its origin and significance, and repaired as appropriate based on the findings.

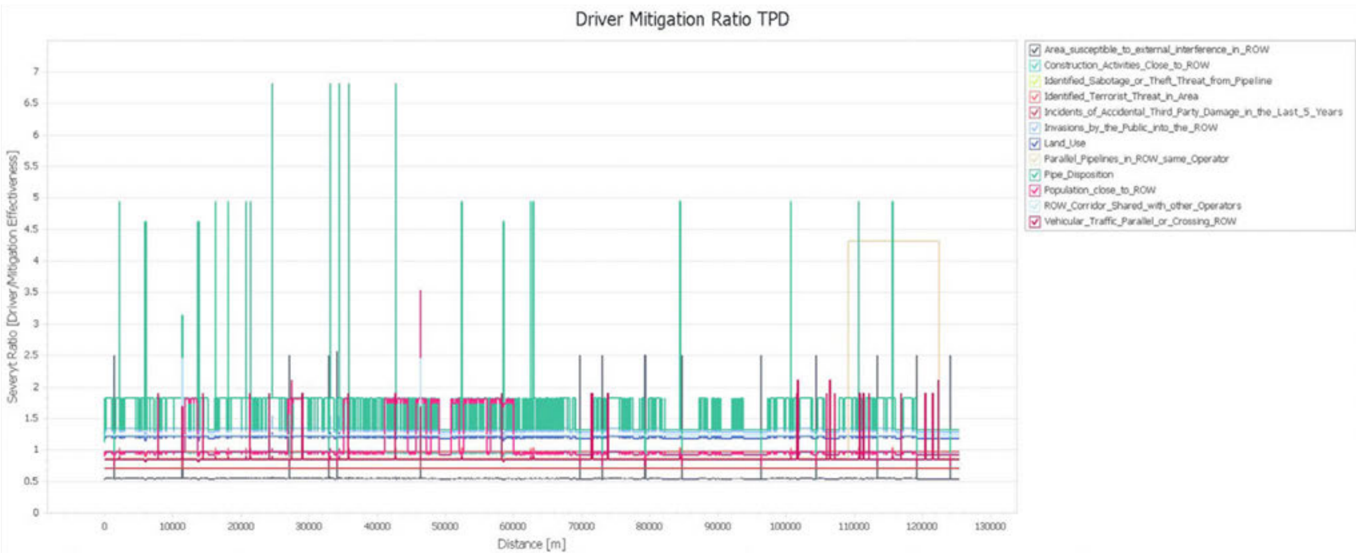


Figure 5: RA Results: Driver Mitigation Ratio TPD

Based on the recommendations from IMP, a sensitivity analysis was performed to evaluate the risk-reduction effectiveness of these actions before their implementation. This resulted in a reduction in the PoF profile, as shown in Figure 6.

As can be noticed, the implementation of some mitigation actions is able to significantly reduce the risk. Table 2 shows the comparison between total length in each risk category before and after the mitigations. The 78% reduction of total length in the high-risk category is remarkable.

	Original	After mitigations
Risk Category	Length (m)	Length (m)
Very Low	108662.90	108662.90
Low	12702.83	12810.85
Medium	2668.36	3727.69
High	1505.85	338.51

Table 2: Length by risk category comparison

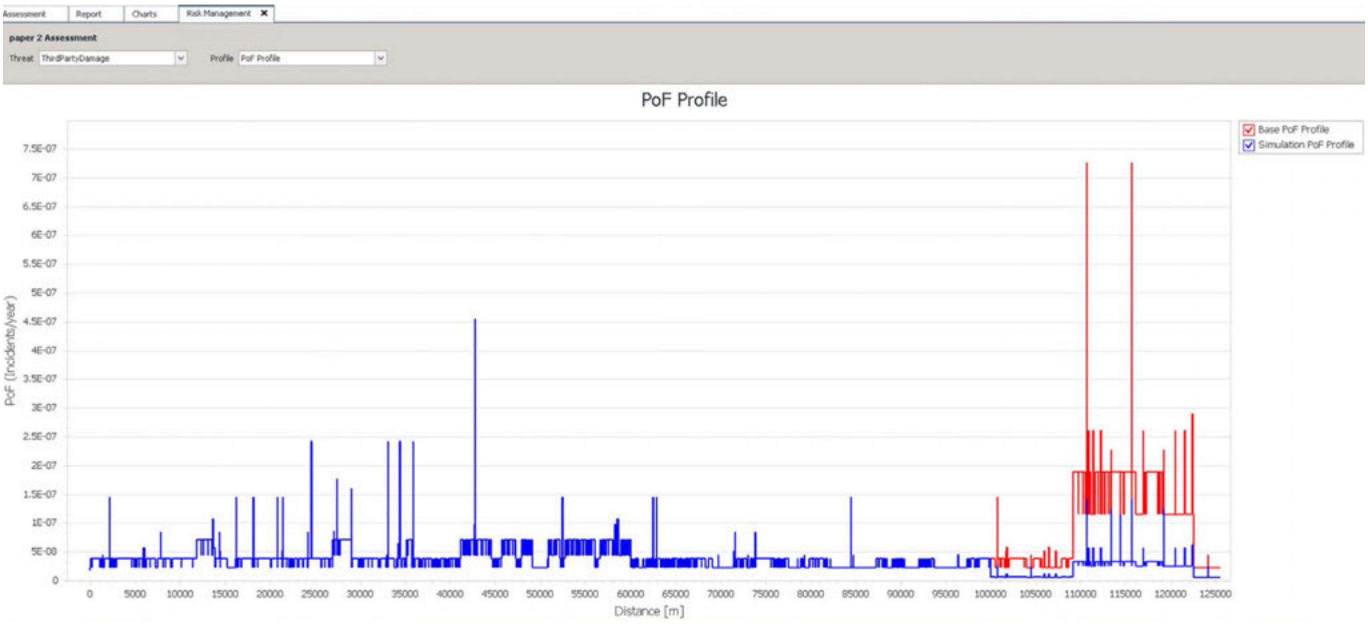


Figure 6: RA Results: PoF profile comparison (before and after mitigations)

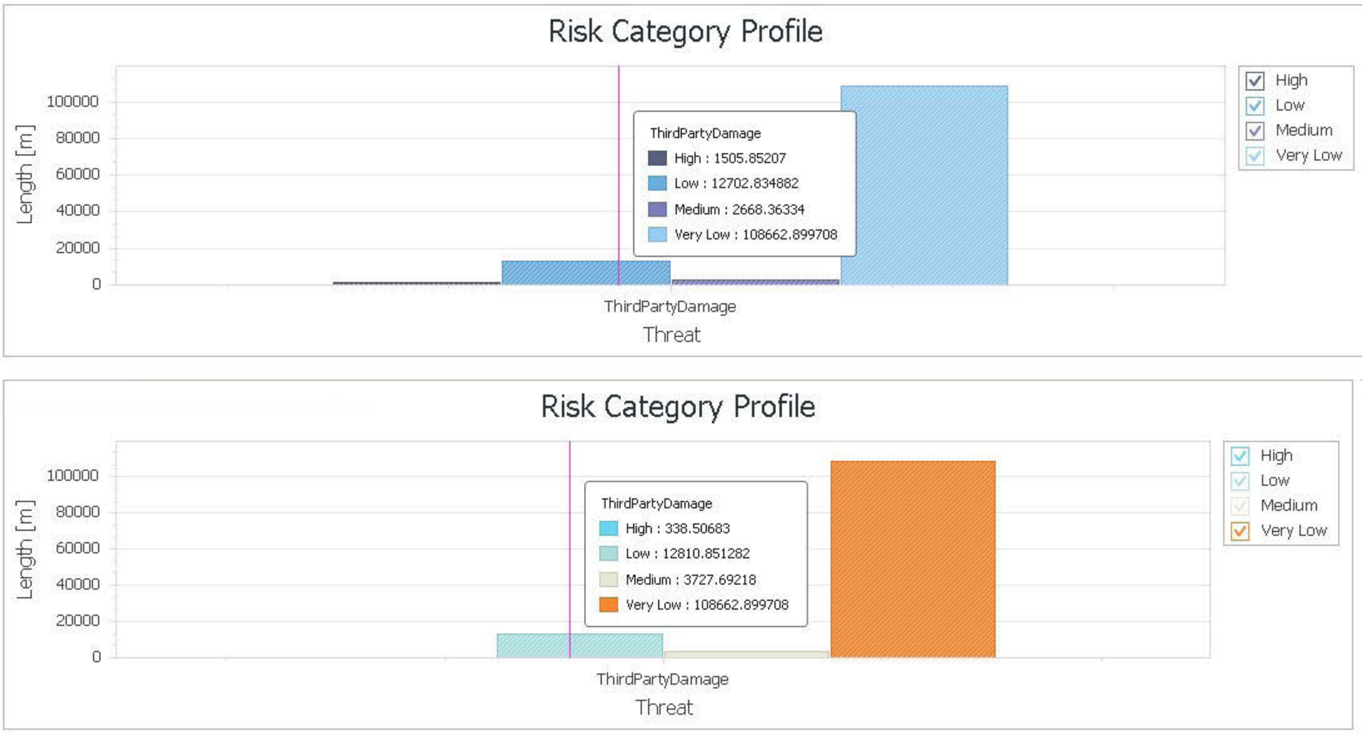


Figure 7: RA Results: Risk for TPD (before and after mitigation)

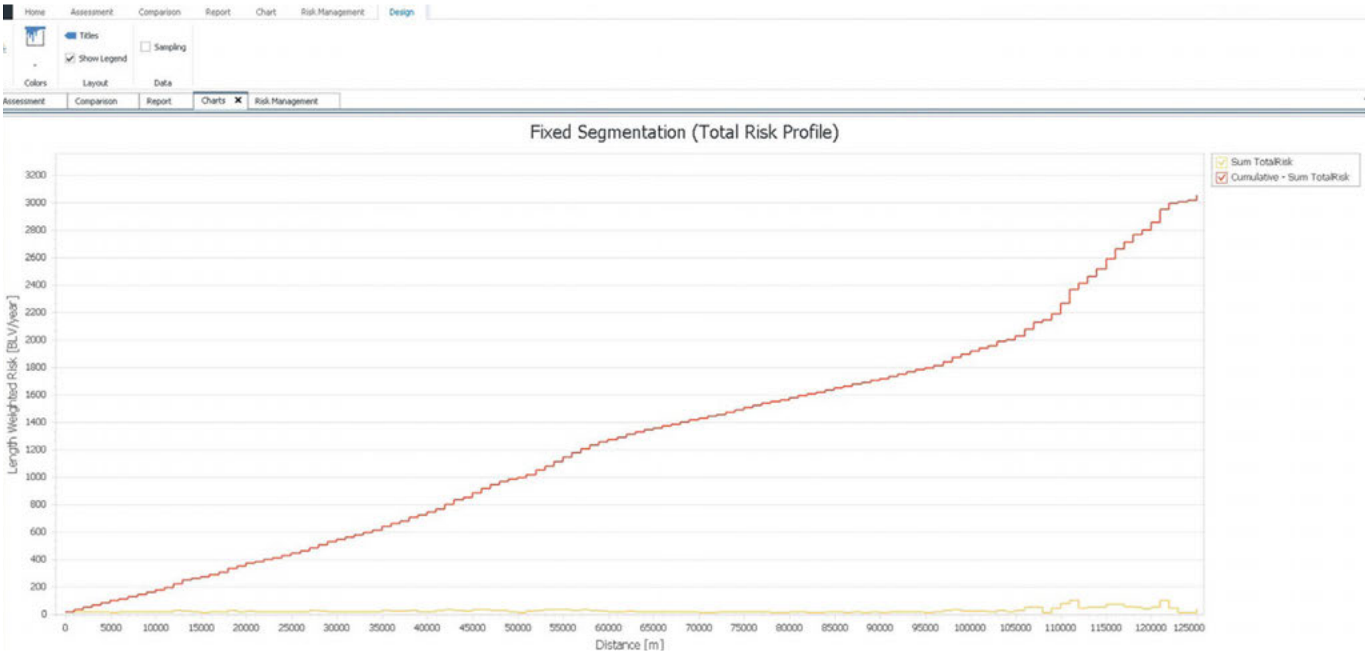


Figure 8: RA Results : Cumulative risk (after mitigations on TPD)

After implementing these simple actions, the highest risk value is 100 BLV/year at ~111000 m, corresponding with one populated area. At the previous location with highest risk at ~121000 m the risk value was reduced to 97 BLV/year. With these actions the cumulative risk was reduced by 6% (cumulative risk is now 3,058 BLV/year).

CONCLUSION

As was explained, ROSEN's Quantitative Pipeline Risk Assessment Model (QPRAM) is a methodology that takes into account the particular conditions for each operator, which is a great advantage over other available methods.

Particularly noteworthy is the ability to perform this kind of analysis after risk assessment, making this is a powerful tool that allows operators to optimize resources. This is especially welcome when dealing with restrictions.

Operators can also define a maintenance plan based on their possibilities and available resources through sensitivity analyses that help them assess the optimized risk treatment options.

As a result, reactive maintenance will tend to decrease as proactive maintenance increases, leading to a reduction of the maintenance budget and ultimately a more reliable system.

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[4] DNV RP F116, Integrity Management of submarine pipeline systems, 2017
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DENSO GROUP GERMANY – DENSOLEN® USED FOR FIELD-JOINT COATING ON HIGH-PRESSURE NATURAL GAS LINES IN UPPER BAVARIA, GERMANY

DENSO Group Germany, manufacturer of corrosion prevention systems for welded seam coatings, rehabilitation and complete pipe coatings, is supplying corrosion prevention materials for approximately 3,000 steel pipe welded seams for the construction of the MONACO transport line in the east of Munich.

The DENSOLEN® 2-tape system – proven over decades of use – will be installed on a 40-kilometre stretch of pipeline with nominal diameters of up to DN 1200, using highly developed application equipment. The DENSOLEN®-N60/-S20 system is designed for use at consistently high operating temperatures, making it the ideal solution for this long-distance natural gas line, which can withstand pressures of up to 100 bar. The tape system has convinced in other major pipeline projects such as OPAL and NEL in Germany.

Reliable and precise application of corrosion prevention tape using automatic machine technology

For the customer, automation is a very important consideration. The petrol-fuelled or electric DENSOMAT®-11 wrapping devices guarantee a high level of application reliability, and automatically maintain a constant winding tension and overlap width. Three of these machines will be available for use on the pipeline. Mr. Bockstaele, Head of QSHE at the leading construction company DENYS, mentioned that due to the DENSOMAT®-11 the workload of the workers could be reduced as this wrapping device is "easily twice as fast" as manual application equipment.

The smaller winding device DENSOMAT®-KGR Junior is manually operated, light and exceptionally flexible. It is ideal for coating of short pipe bends or for use on sites that are difficult to access, such as the steep slope that will present an installation challenge in this project.

With the DENSOLEN® tape systems and the accompanying specially designed, reliable DENSOMAT® wrapping devices, DENSO is providing a complete corrosion prevention solution for the field-joint coating of the steel pipes.

The MONACO long-distance natural gas line ensures that gas can be transported as required from and to the large natural gas storage facilities in Bavaria and Austria. Completion of the work is scheduled for 2018; the new pipeline will be commissioned later that year.

More information is available at www.denso.de.

Steep slope at the installation site of the high-pressure gas line MONACO in Upper Bavaria

Contact: Michael Schad
Head of Sales International
Email: schad@denso.de

Fast and precise application of DENSOLEN®-N60/-S20

Reliable application with the DENSOMAT®-11

TAL - Transalpine pipeline commissions world's first crude oil "run-of-pipeline" power plant

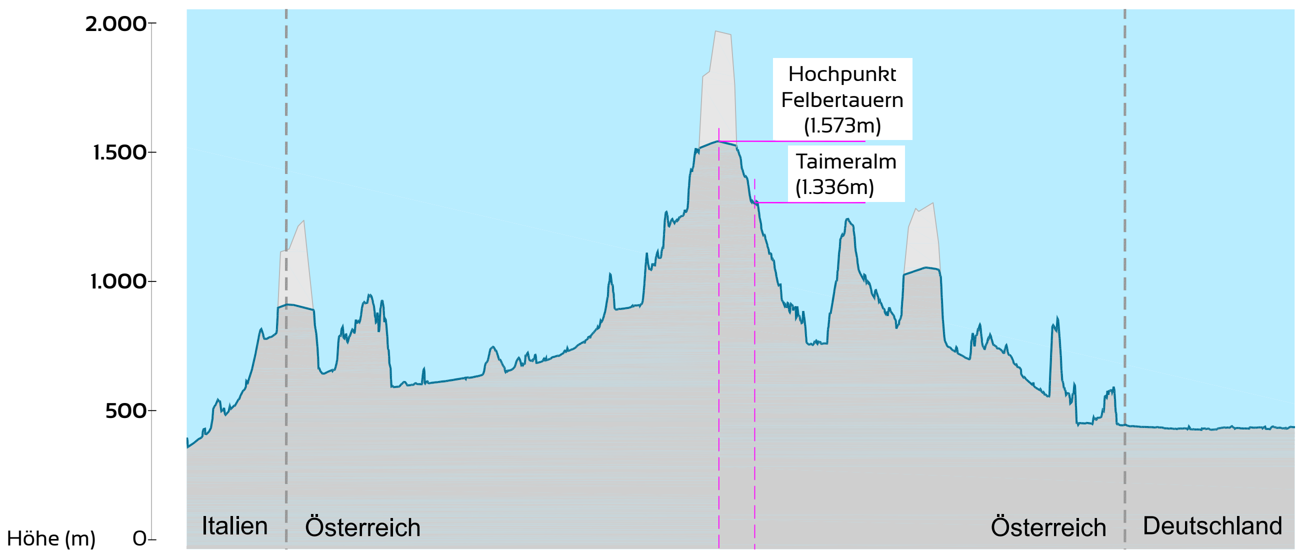
Crude oil flow becomes electricity - at least in the Austrian Alps. The TAL - Transalpine Oil Pipeline - which delivers crude oil from Trieste, Italy, via the Alps to Germany and Austria, put the first crude oil "run-of-pipeline" power plant worldwide in operation on the 21st of September 2018.

The plant is able to produce emission-free electricity, using the same principle as the hydroelectric power plants: the kinetic energy of the crude oil is used to drive a turbine that produces the electricity. Local geography makes this possible, because of one the major challenges the TAL has to face - the differences in altitude along the pipeline route, which add-up to 1,600 meters. TAL has now developed an innovative method of generating electricity along the longest downfall along its route.

The kinetic energy of the crude oil is built up by the downfall and drives a turbine in the valley below. It is noteworthy that this is a Francis-Turbine, the first ever to be installed in a crude oil pipeline. The turbine is a product of the Austrian company Global Hydro and TAL has installed it at the Taimeralm in the municipality of Mittersil at an altitude of 1,335 meters above sea level. Alessio Lilli, General Manager of the TAL Group, stressed that "with this globally unique project, the TAL will make a contribution to environmentally friendly energy supply in Austria and significantly increase its energy efficiency".

Project manager Markus Mühlmann describes the capacity of the unique project at the ceremonial inauguration of the plant: "The annual working capacity is around 11.5 GWh. The maximum continuous output in normal operation is 2,500 kW." The amount of energy generated corresponds to around twelve percent of the current energy consumption of the local segment of the Transalpine pipeline and could supply 3,000 households. In 2017, a volume of 42.4 million tons of crude oil flowed through the TAL. Compared to the previous year, this is an increase of 2.4 percent.

ILF Consulting Engineers Austria GmbH was responsible for planning the plant. The construction took three years and required an investment of 11 million €. Another characteristic of the Taimeralm facility is its location in the heart of a national park. To ensure that the plant fits in well with its surroundings, it was built with a green roof and a wooden facade.



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ptc 2019 offers again opportunities for operators as well as technology and service providers to exchange latest onshore and offshore technologies and new developments supporting the energy strategies world-wide. More than 700 delegates and 80 exhibitors are expected to participate in the 14th ptc in Berlin.

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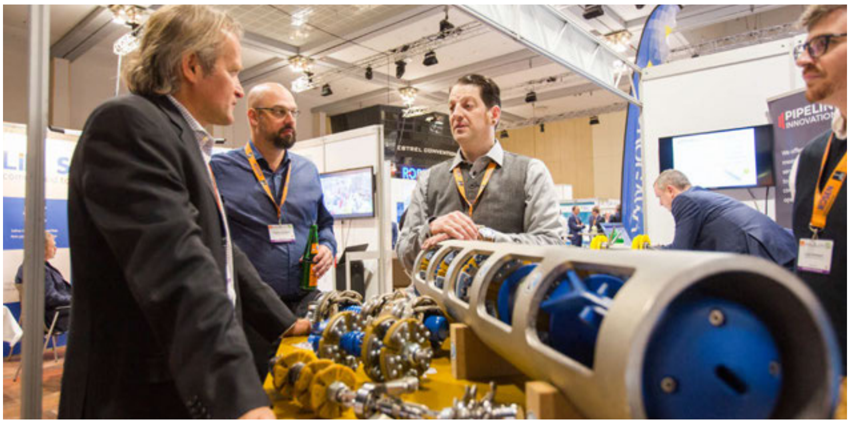

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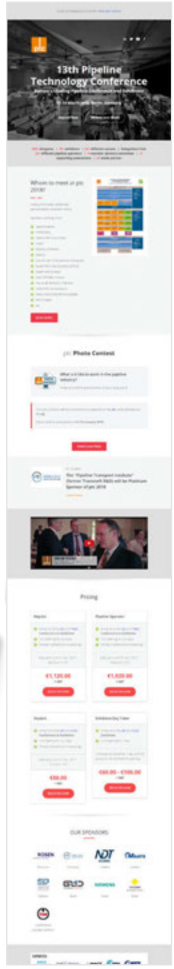
- ptc Website
- Pipeline Technology Journal (ptj)



30K Verified Addresses

22 Media Partners

16 Supporting Associations

42 Advisory Committee Members

>2K Followers on social networks

Get in touch with us if you would like to get to know more about our sponsoring Opportunities.

CONFIRMED EXHIBITORS AS OF 25.10.2018

REGISTER YOUR STAND AT
WWW.PIPELINE-CONFERENCE.COM/STAND-BOOKING

- 50+ DIFFERENT NATIONS
- DELEGATIONS FROM 70+ DIFFERENT PIPELINE OPERATORS FROM ALL AROUND THE WORLD
- 700+ DELEGATES
- 80+ EXHIBITORS
- 100+ PRESENTATIONS
- 25 TECHNICAL SESSIONS
- ACCOMPANYING SCIENTIFIC POSTER SHOW

THEMATIC FOCUSES:

CONSTRUCTION
CORROSION PROTECTION
CYBER SECURITY
FIBER OPTIC SENSING
INLINE INSPECTION
INTEGRITY MANAGEMENT
LEAK DETECTION
MAINTENANCE & REPAIR
MATERIALS
OFFSHORE TECHNOLOGIES
OPERATIONAL IMPROVEMENTS
PLANNING & DESIGN
PUMP & COMPRESSOR STATIONS
QUALIFICATION & RECRUITMENT
TRENCHLESS TECHNOLOGIES
VALVES & FITTINGS

JOB & CAREER MARKET

YOUR OPPORTUNITY TO ATTRACT PROFESSIONALS AND HIGH POTENTIALS

The international pipeline community is in need of additional personnel.

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

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

ptc side conference on

Qualification and Recruitment

18 March 2019
Estrel Convention Center Berlin, Germany

In the frame of ptc

ONE SERVICE - MULTIPLE CHANNELS

International Universities

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

Website

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

Biweekly Newsletter

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

International Events

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

Questions?

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

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

You get:

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

Association

IAOT - International Association of Oil Transporters
Czech Republic
www.iaot.eu/

DVGW - German Technical and Scientific Association for Gas and Water
Germany
www.dvgw.de

Automation

Siemens
Germany
www.siemens.com

Yokogawa
Japan
www.yokogawa.com

Certification

Bureau Veritas
Germany
www.bureauveritas.de

DNV GL
Norway
www.dnvgl.com

TÜV SÜD Indutrie Service
Germany
www.tuev-sued.de/is

Cleaning

Reinhart Hydrocleaning
Switzerland
www.rhc-sa.ch/rhc/

Coating 1/2

Denso
Germany
www.denso.de

Kebulin-gesellschaft Kettler
Germany
www.kebu.de

Coating 2/2

Polyguard Products
United States
www.polyguard.com

Premier Coatings
United Kingdom
www.premiercoatings.com/

RPR Technologies
Norway
www.rprtech.com/

Shawcor
United States
www.shawcor.com

TDC International
Switzerland
www.tdc-int.com

TIAL
Russia
www.tial.ru

TIB Chemicals
Germany
www.tib-chemicals.com

Construction 1/2

BIL
Germany
bil-leitungsauskunft.de

Herrenknecht
Germany
www.herrenknecht.com

IPLOCA - International Pipe Line & Offshore Contractors Association
Switzerland
www.iploca.com

MAX STREICHER
Germany
www.streicher.de/en

Petro IT
Ireland
www.petroit.com

Construction 2/2

VACUWORX
Netherlands
www.vacuworx.com

Vlentec
The Netherlands
www.vlentec.com

Construction Machinery

Maats
Netherlands
www.maats.com

Worldwide Group
Germany
www.worldwidemachinery.com

VIETZ
Germany
www.vietz.de

Engineering

ILF Consulting Engineers
Germany
www.ilf.com

KÖTTER Consulting Engineers
Germany
www.koetter-consulting.com

Inline Inspection 1/2

3P Services
Germany
www.3p-services.com

A.Hak Industrial Services
Netherlands
www.a-hak-is.com

Intero Integrity Services
Netherlands
www.intero-integrity.com/

KTN AS
Norway
www.ktn.no

Inline Inspection 2/2

LIN SCAN
United Arab Emirates
www.linscaninspection.com

NDT Global
Germany
www.ndt-global.com

Pipesurvey International
Netherlands
www.pipesurveyinternational.com

PPSA - Pigging Products and Services Association
United Kingdom
www.ppsa-online.com

Romstar
Malaysia
www.romstargroup.com

Rosen
Switzerland
www.rosen-group.com

Inspection

Ametek – Division Creaform
Germany
www.creaform3d.com

Applus RTD
Germany
www.applusrtd.com

EMPIT
Germany
www.empit.com

Integrity Management

Metegrity
Canada
www.metegrity.com

Pipeline Innovations
United Kingdom
www.pipeline-innovations.com

COMPANY DIRECTORY

Leak Detection

Asel-Tech
Brazil
www.asel-tech.com

Atmos International
United Kingdom
www.atmosi.com

Direct-C
Canada
www.direct-c.ca

Entegra
United States
www.entegrasolutions.com

GOTTSBERG Leak Detection
Germany
www.leak-detection.de

MSA
Germany
www.MSAsafety.com/detection

OptaSense
United Kingdom
www.optasense.com

Pergam Suisse
Switzerland
www.pergam-suisse.ch

PSI Software
Germany
www.psioilandgas.com

sebaKMT
Germany
www.sebakmt.com

SolAres (Solgeo / Aresys)
Italy
www.solaresweb.com

Monitoring

Krohne Messtechnik
Germany
www.krohne.com

Operators

TRAPIL
France
www.trapil.com/en/

Pump and Compressor Stations

TNO
The Netherlands
www.pulsim.tno.nl

Repair

CITADEL TECHNOLOGIES
United States
www.cittech.com

Clock Spring
United States
www.clockspring.com

RAM-100
United States
www.ram100intl.com

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

Research & Development

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

Safety

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

HIMA
Germany
www.hima.de

Signage

Franken Plastik
Germany
www.frankenplastik.de/en

Surface Preparation

MONTI - Werkzeuge GmbH
Germany
www.monti.de

Trenchless Technologies

GSTT - German Society for Trenchless Technology
Germany
www.gstt.de

Rädlinger Primus Line
Germany
www.primusline.com

Valves & Fittings

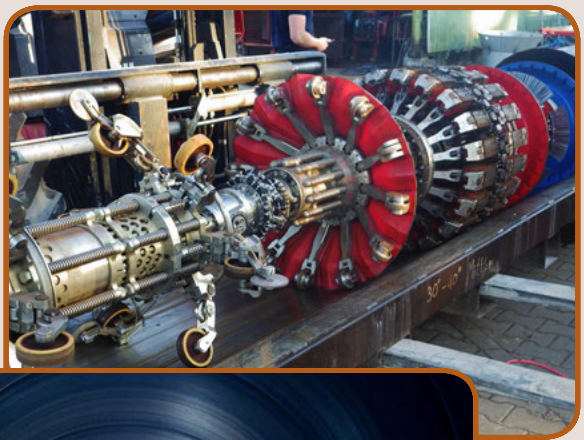
AUMA
Germany
www.auma.com

Zwick Armaturen
Germany
www.zwick-armaturen.de

December 2018

In the next Edition of ptj:

Integrity Management



The next issue of Pipeline Technology Journal (ptj) will address Integrity Management.

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

GET TO KNOW EITEP

Euro Institute for Information and Technology Transfer

Dr. Klaus Ritter
President Eitep

Conferences & Exhibitions

Dennis Fandrich
Vice President

Marian Ritter
Director Exhibitions

Marketing & Communication

Rana Alnasir-Boulos
Vice President

Admir Celovic
Director Publications

Project Assistants

As of 25.10.2018

The EITEP Institute is providing Know-How and Technology-Transfer through international Conferences, Seminars and Publications. Our primary objective is to foster the international exchange of state-of-the-art-technologies, in order to provide the latest products and services where they are needed.

EITEP is organized in two departments, guided an overseen by the company's president, Dr. Klaus Ritter, who worked as general manager for professional, technical and scientific associations of the German energy and water supply sector before becoming the founder and president of EITEP.

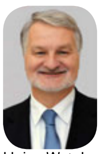
Conferences & Exhibitions

The department Conferences & Exhibitions is responsible for the organization of EITEP events, which include the upcoming Pipeline Technology Conference. Also, all exhibitions associated with these events are planed and executed by this department. It is led by Mr. Dennis Fandrich, who is your contact for all matters regarding the Conferences. The exhibitions are organized by Mr. Marian Ritter, he will assist you with all questions regarding the fairs.

Marketing & Communication

The department Marketing & Communication planes and executes all activities related to the promotion of EITEP events and the communication with stakeholders. It is responsible for the publication of professional magazines like the Pipeline Technology Journal (ptj). The department is led by Mrs. Rana Alnasir-Boulos, she is your contact regarding marketing, sales, seminars and special projects. Responsible for our publications is Mr. Admir Celovic. He will assist you with questions regarding the journals editorial content and advertisement opportunities.

EITEP is supported by the advisory committee AdCo, which consists of 44 senior pipeline professionals from all over the world. They bring in the necessary connection to the profession and valuable technical expertise. To further support our efforts. All presentations held during our conferences and all publications released by EITEP are checked by the AdCo before cleared for publication. The Advisory Committee is currently led by Heinz Watzka, former Managing Director Technical Services at Germany's biggest pipeline operator, Open Grid Europe, and Dirk Strack, Technical Director at TAL Group. Additional senior consultants have been recruited as advisors for special issues.


Heinz Watzka


Dirk Strack

Event Calendar		
ADIPEC	12 - 15 November 2018	Abu Dhabi, UAE
14th Pipeline Technology Conference (ptc)	19 - 21 March 2019	Berlin, Germany
ptc Side Conferences: on Qualification & Recruitment on Public Perception	 18 March 2019 18 March 2019	 Berlin, Germany Berlin, Germany

ptj Pipeline Technology Journal

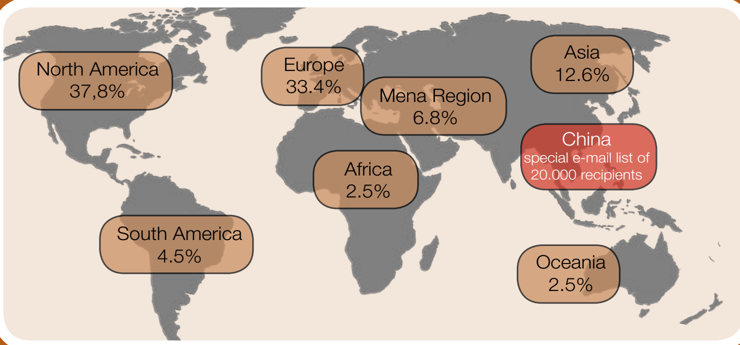
You have interesting content
to share with the global pipeline community?

Submit an Article!

Use ptj as a platform to report about your news, projects, innovations and technologies. If you are interested in submitting insightful technical articles to be considered for the ptj, please send us an abstract for review.

You want to enhance or maintain
your international visibility as a company?

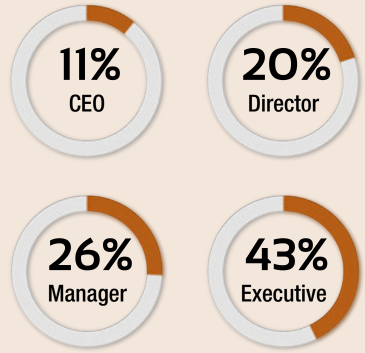
Book an Advertisement !



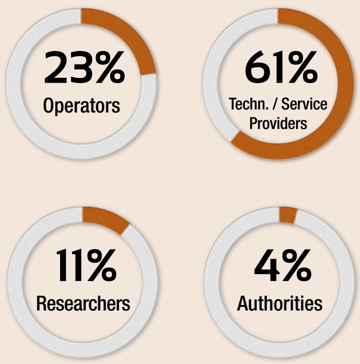
The ptj-brand offers a multitude of advertisement opportunities to increase visibility and reputation toward pipeline professionals worldwide. Make use of the extensive ptj-portfolio and reach over 30,000 Experts.

ptj-brand-audiences

Audience Job Levels



Company types



A manifold database

We deliver content to local practicioners and global decision-makers alike, making the ptj-brand a suitable tool for global knowledge distribution as well as developing and upholding overall visibility in the global pipeline industry.