

# Pipeline Integrity Management System

By Markus Ruhe and Frank Rathlev

## 1 Introduction

In order to ensure that gas transport lines operate with as little damage and environmental impact as possible while still being economic, Thyssengas GmbH operates a Pipeline Integrity Management (PIM) system. The task of PIM is to determine the overall process for the integrity assessment of lines and thus to control the operative implementation of inspections, maintenance, and repairs of the line network.

In this connection, Thyssengas GmbH introduced a Pipeline Integrity Management System in 2010. The goal was to provide system-technical support for the PIM sub-processes for the determination and evaluation of the line condition.

This technical paper describes the procedure for integrity evaluation and its system-technical implementation as used by Thyssengas GmbH.

## 2 Pipeline Integrity Management / System

The installation of high-pressure gas pipelines follows applicable construction norms and relevant DVGW worksheets in order to ensure the integrity of the line during installation. During pipeline operation, maintenance is of essential importance for the sustaining technical integrity.

Preserving technical integrity and the need to use suitable management systems is required by the relevant regulations of DVGW<sup>1</sup>, European regulations<sup>2</sup>, and GasHDrLtgV. The creation of a unified European guideline for security management system for natural gas transport pipelines is in progress.

The goal of Pipeline Integrity Management (PIM) for gas transport pipelines is to ensure operations with as little damage and environmental impact as possible while still being economic.

Fig. 1 describes the interaction between the maintenance measures to be performed in order to minimize potential risk and the resulting financial expenses. The possibility of creating a balance between both aspects depends mainly on knowledge of the network status.

---

<sup>1</sup> DVGW G401, G463, G469, G465, G466-1, GW 10, GW1200 G1000

<sup>2</sup> DIN EN 1596, DIN EN 12327, DIN EN 12007-1,

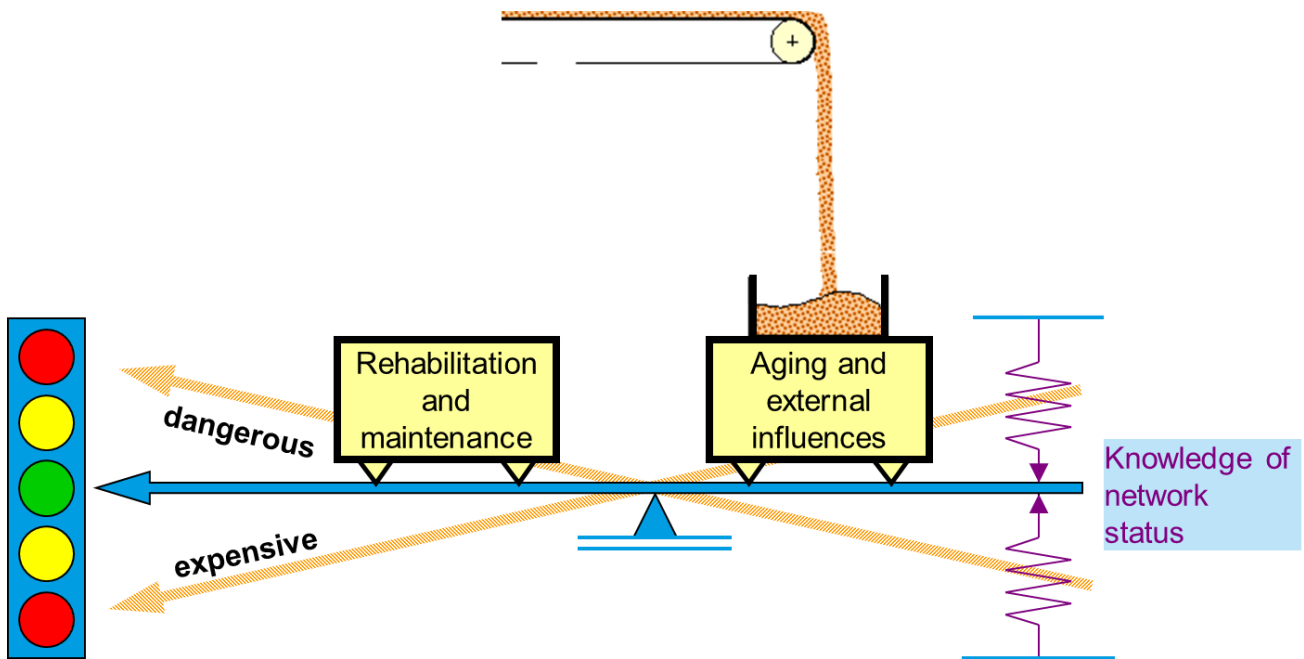


Fig. 1: Interaction between potential risk and expense

Based on the knowledge of the status, suitable rehabilitation and maintenance measures can be planned. The derivation of measures requires a standardized description of the pipeline status and a uniform status assessment.

The status assessment (integrity) of a pipeline is obtained by consolidating and evaluating various sources of information. They arise from the areas of operational organization, data documentation, and technical operational management.

The task of PIM is to determine the overall process for the integrity evaluation of lines and thus to control the operative implementation of inspections, maintenance, and repairs of the pipeline network. It thus forms the connection between management, organization, information, and technology.

During the introduction of the Pipeline Integrity Management of Thyssengas GmbH, we identified in particular three integrity characteristics.

- **Technical integrity:**  
 Technical integrity is the sum of operational safety, availability, and environmental friendliness. It is assumed when both planning / installation and maintenance (inspection, maintenance, repair, shutdown, and decommissioning) of gas transport systems are performed in accordance with regulations and expert have approved deviations.

- **Organizational integrity:**  
Thyssengas GmbH has been audited pursuant to DVGW TSM (= technical security management). Certified auditors of the DVGW performed and confirmed this audit to verify the organization, procedures, and processes, in order to ensure that organizational integrity is given.
- **Data and information integrity:**  
Data and information integrity is the continuous availability of the data and information necessary to prove technical integrity.

PIM thus encompasses the complete life cycle of a gas transport line. It consists of planning, construction, start-up, maintenance, and decommissioning.

In order to prove and maintain technical integrity, PIM is supplemented by a Pipeline Integrity Management System (PIMS) (Fig. 2).

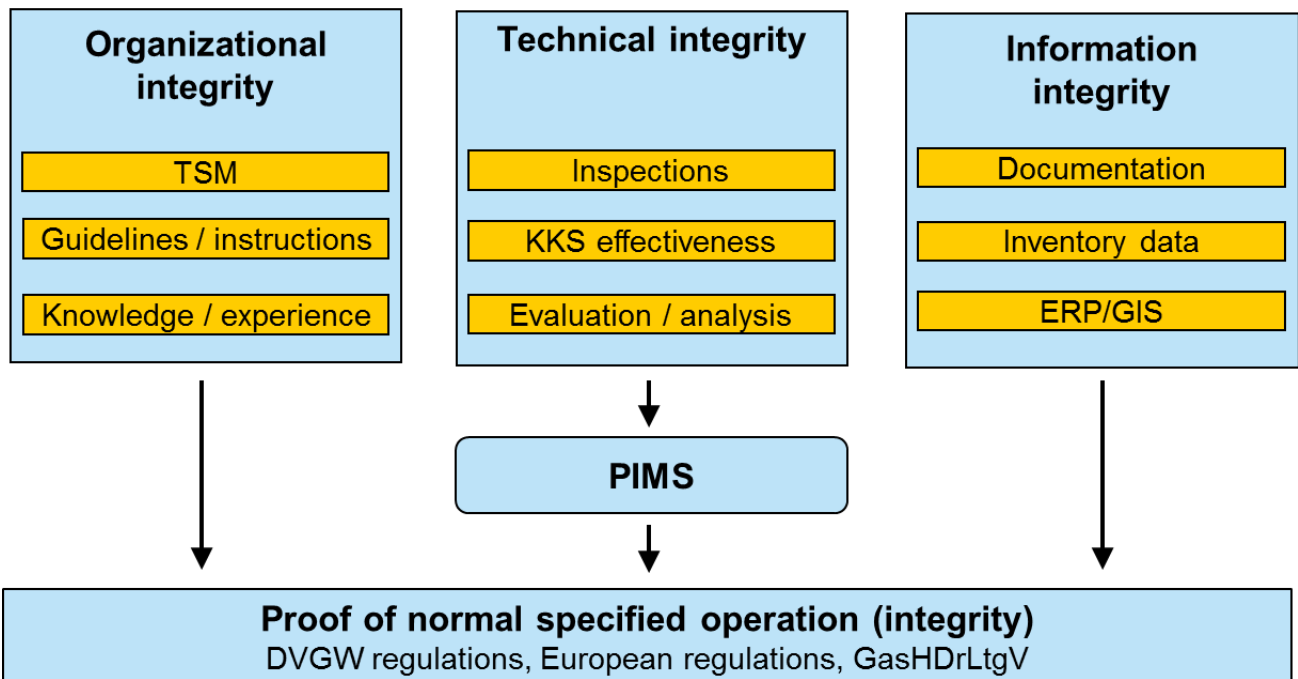


Fig. 2: PIM - Pipeline Integrity Management

PIMS has the task to support the sub-processes affecting Pipeline Integrity Management. The determination of the pipeline status (integrity) that is to result in an evaluation proposal is based on the current regulations.

The relevant input data and parameters are collected from the various source systems and consolidated in PIMS. The consolidation basis is defined by a common status assessment in the line system.



PIMS offers the possibility of making the evaluation results available to various user groups in a usage-related and plausible fashion.

PIMS archives all data and formulas used in the line assessment together with the result in an audit-proof manner.

### 3 PIMS – Process

The use of PIMS at Thyssengas GmbH should be integrated into the existing operative processes of the network technology from the beginning. The correct placement of the software was guaranteed by including all involved parties with asset responsibilities early on.

We will now sketch the maintenance process and the PIMS process (Fig. 3).

In general it is necessary to determine the pipeline status of the entire line network. Furthermore, any inspections performed during operations and individual inspections can lead to an integrity evaluation.

Initiated by network operations, the pipeline is evaluated in PIMS. By involving network engineers and experts in the evaluation of the result, any peculiarities of a pipeline can be considered. If there is a good reason to do so, further inspection measures can be recommended. Information garnered from this are then considered in a new evaluation run.

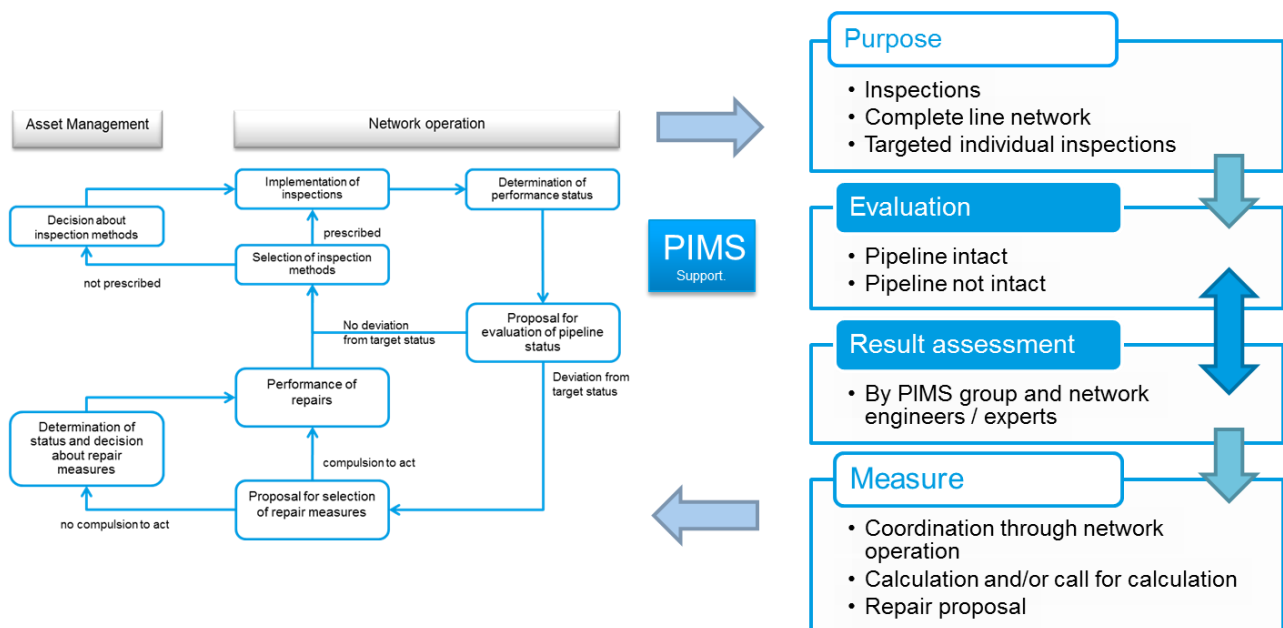


Fig. 3: PIMS - process integration

The following describes the system-technical procedure of the technical integrity evaluation in the Thyssengas PIMS (Fig. 4).

The input data for the integrity evaluation come mainly from the data of the employed GIS system, the KKS management system, and data from performed inspection measures (KKS - intensive measurements and in-line inspections/piggings).

The inspection data are entered into the Smallworld GIS<sup>®</sup> and geo-referenced by adjusting for the equipment. Corresponding functionalities consolidate the equipment data and inspection results for the line segment to be evaluated. Afterwards, the summarized data are exported as input data for the integrity evaluation.

The KKS management system supplies further input data relevant for the evaluation. They consist of information about KKS protective systems, soil values, and KKS effectiveness.

Trascue PIMS<sup>®</sup> prepares the different input data and forms dynamic segments. Missing input data are supplemented by estimates.

The corrosion calculation developed during the project calculates possible corrosion damage from all available equipment and KKS information. This calculation is performed considering the different states in the life cycle of the pipeline.

Finally, the integrity evaluation of the pipeline is performed using stress evaluation. In addition, a ranking is performed to determine reconstruction priorities.

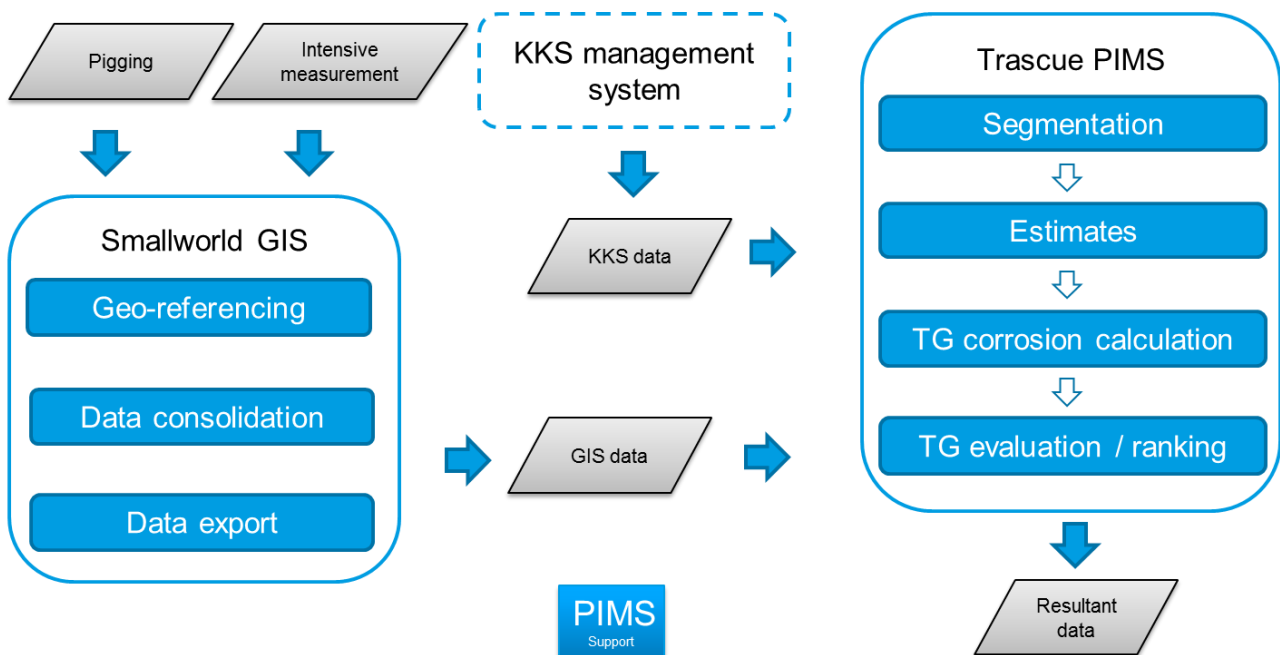


Fig. 4: System-technical procedure of Thyssengas PIMS



### 4 System components

The evaluation algorithms and other individual functionalities were implemented and configured based on the standard software Trascue PIMS<sup>®</sup>. The input data are mainly consolidated in Smallworld GIS<sup>®</sup>.

System component	Function
Smallworld GIS <sup>®</sup>	Preparation of equipment data and geo-referenced inspection data
KKS management system	Preparation of KKS data (safety systems, measurement data...)
Trascue PIMS <sup>®</sup>	Data collection / archiving Integrity evaluation Presentation of results

We will now explain the functions of the employed system components of the Thyssengas PIMS.

#### 4.1 Smallworld GIS<sup>®</sup>

Thyssengas GmbH uses Smallworld GIS<sup>®</sup> with the expanded application “Fachschale Ferngas” to support geo-related business processes, in particular the sub-process of pipeline documentation. During the PIMS introduction, the existing GIS was extended by the standard modules GeoCP and GeoLI for the display of inspection data. In addition, the PI Data Manager for data preparation was implemented.

##### 4.1.1 Adjustment of inspection data

The input data from the various inspection measures need to be projected onto the documented geographical position of the gas transport pipelines. The main geo-reference is the position information of the GIS system.

The Thyssengas PIMS is capable of processing in-line inspection data from piggings and data sets from KKS intensive measurements. For this, adjusted inspection data are loaded into Smallworld GIS<sup>®</sup> and referenced to the documented course of the pipeline through the determination of identical points.

Significant events such as coating defects or decreases in wall thickness can thus be evaluated in the overall context of equipment information and as passed on as input data to the integrity evaluation.



### 4.1.2 Data provision from GIS

The dynamic segmentation needed for the integrity evaluation requires consolidation of the equipment and inspection data. The complex data structures of GIS are reduced to the input data needed for the integrity evaluation and is transferred into a linear data system. The data is provided in exchange files in XML format.

### 4.2 KKS - management system

The KKS management system of Thyssengas GmbH which is under construction supports the organizational and technical processes of cathodic corrosion protection (KKS).

The KKS management system provides important input data for the corrosion calculation and ranking as part of the technical integrity evaluation. The data is exchanged over a firmly defined interface.

### 4.3 Trascue PIMS®

The algorithms and functionalities developed for line classification, corrosion calculations, and technical integrity evaluation as part of the PIMS project were implemented into Trascue PIMS®.

#### 4.3.1 Formation of segments

PIMS prepares the various input data. When evaluation-relevant attributes in the line system change, segments are formed. The number of segments changes depending on the selection of the relevant attributes and their extent in the line system. The segmentation defines sections of equal input data (Fig. 5) that allow for a clear integrity evaluation valid for that section.

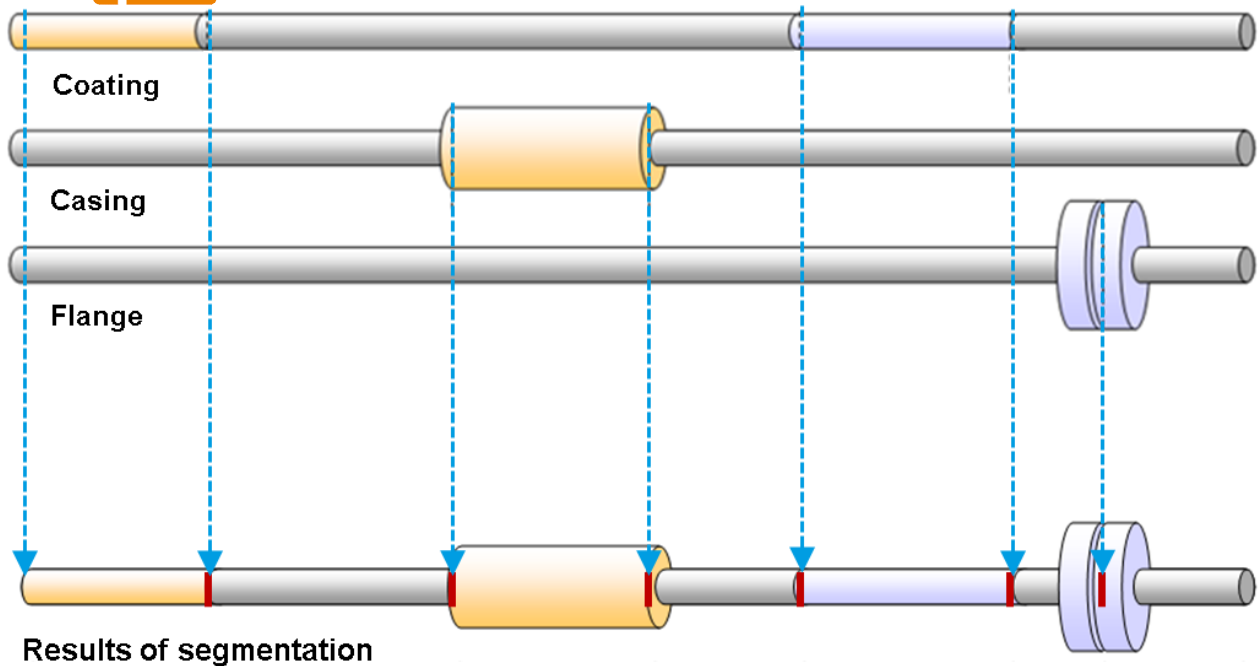


Fig. 5: Dynamic segmentation

#### 4.3.2 Complete and consistent input data

The integrity evaluation in Thyssengas PIMS requires consistent and complete input data. In practice, the required information is not always available or the data are variable and are not recorded in the equipment documentation of GIS.

The missing data are researched in accordance with the procedure defined in the PIMS process and fed into the integrity evaluation through the equipment documentation. If the data research does not come up with any result, Thyssengas PIMS can set estimated values.

The estimates are set either automatically from classification tables or manually based on experience values. The use and change of estimates are logged in the system in a traceable manner.

The completeness of the input data is ensured through predefined plausibility rules and manual data checks.





### 4.3.3 Corrosion calculation

A special form of estimates is corrosion calculations. This functionality integrated into the Thyssengas PIMS delivers the best possible estimates for the depth of wear even without verified input data. The values are replaced when the actual measured depth of wear is determined (pigging, excavation).

The corrosion calculation assumes that the data basis for the evaluation is available for different depths for different gas transport pipelines. This mainly affects soil information but also the efficiency proof of protective measures. Missing criteria must first be sensibly estimated or assumed.

The max. corrosion rate is determined considering the following influences:

- Year of construction, installation and coating type
- Soil class and/or resistance (geo-data)
- Distance to foreign objects
- History of corrosion protection

Based on the input data, factors and/or corrosion rates are deduced through corresponding connections and/or dependencies that enter into the individual calculations as parameters and finally lead to the calculation of an overall corrosion rate. This corrosion rate is then multiplied with the time factor and results in a prognosis for corrosion wear for the considered period.

### 4.3.4 Technical evaluation

The integrity of gas transport pipelines is described by the result of a stress evaluation. The stress evaluation is used to calculate the relationship between the stress on a pipeline and its resistivity.

The stress is calculated along the circumference using the pipe formula against the relevant load case of interior pressure. Local wall thickness reductions, bumps, and traffic and soil loads are also considered. The result of the stress evaluation leads to a pass / fail statement ("red / green" view). There is a compulsion to act as soon as the calculation returns a fail (red) value.

In addition, the total utility (utility value) is calculated for each segment using a utility value function. This process evaluates variously weighted criteria from environmental influences, pipe and coating conditions, economic viability, and construction using a uniform value scale.

The resulting ranking supports the systematic selection of pipelines that need to be inspected or repaired without there being an immediate compulsion for action for these lines.

### 5 Conclusion and outlook

Thyssengas GmbH operates a Pipeline Integrity Management (PIM). In order to support the technical integrity evaluation, a Pipeline Integrity Management System (PIMS) was introduced in 2010.

During an intensive specification phase we defined evaluation algorithms to perform the integrity assessments based on the current regulations.

The assessment of the line integrity is performed using the stress evaluation developed as part of the project. It determines the relation between stress and resilience of the line under consideration. The result is compared to pre-determined threshold values and thus enables to make a decisive statement concerning the integrity of the line.

In addition, a ranking system was designed that determines reconstruction priorities. This is done by determining characteristic values using a utility value function.

Another focus lay on the development of a corrossions evaluation. A prognosis of the possible corrosion damage is calculated using the applied construction standards, soil information, and the history of the corrosion protection. It is able to deliver the best possible estimates of the corrosion damage even without confirmed input data.

The evaluation algorithms and other individual functions were implemented and configured based on the standard software Trascue PIMS<sup>®</sup>. The input data are mainly consolidated in Smallworld GIS<sup>®</sup>.

The Thyssengas PIMS was started up in April 2011. At the moment we are performing line evaluations and the results are used for the validation of the current PIMS processes and the used evaluation algorithms.

#### Authors:

**Dipl.-Ing. Markus Ruhe**

Thyssengas GmbH  
Hamborner Str. 229  
47166 Duisburg

Tel.: +49 203 5555-2810

E-mail:

[Markus.Ruhe@thyssengas.com](mailto:Markus.Ruhe@thyssengas.com)

Internet:

[www.thyssengas.com](http://www.thyssengas.com)



**Dipl.-Ing. Frank Rathlev**

Thyssengas GmbH  
Hamborner Str. 229  
47166 Duisburg

Tel.: +49 203 5555-2676

E-mail:

[Frank.Rathlev@thyssengas.com](mailto:Frank.Rathlev@thyssengas.com)

Internet:

[www.thyssengas.com](http://www.thyssengas.com)

