EMPIT

Electromagnetic Pipeline Testing GmbH

Our inspection technique and system are certified by TÜV SÜD

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01 // Technique

On the basis of magnetic measurements, EMPIT is a worldwide unique technique enabling to inspect uppiggable pipelines without changing or influencing the running pipeline production mode. As being a non-destructive testing (NDT) technique, special preparations such as cleaning of the pipeline and the usage of special mediums is not necessary. In order to ensure reliability and performance, our technique and the system are certified by 'TÜV-Süd', which is the most acknowledged technical inspection association in Germany.

All unpiggable pipelines are inspected through aboveground inspection (AGI). This is done by analyzing the A. C. magnetic field of the pipeline aboveground. This magnetic field is induced by an inspection current that is introduced into the pipeline. In order to generate the inspection current, we have developed a special current source – shown in the picture below.

Power Generator (left) and Current Source (right)

The EMPIT inspection A.C. current consists of multiple harmonic components in the audio frequency range. The A.C. current with the lowest frequency flows through the whole cross section of the pipe. The A.C. current with the highest frequency flows, conditioned by the skin effect, only immediately under the exterior surface of the pipe.

A pipeline, which does not have any defect, shows a perfectly circular magnetic field. This is valid regardless of the frequency for all A.C. current harmonic components. Over a defect (e.g. caused by corrosion) a slight deformation of the magnetic field appears. This deformation is caused by the impediment of the current flow in the pipe wall and, according to kind of the defect, by straying out the magnetic flux from the pipe wall. The deformation of the outer A.C. magnetic field is frequency-dependent. This deformation is analyzed and recognized by the EMPIT technique up to a pipe depth of 2 m.

Another essential part of our technique is the inspection system. The Sensor Array (SA), seen on the right side of the picture, holds 24 sensors. Each of them measures the horizontal component of the magnetic field. The data is transferred to the Data Collector Module (DCM), which shows direct information of the pipeline on the screen. Data of the magnetic field, the level of the inspection current, the pipeline depth, and the coordinates of the Sensor Array over the pipeline will be stored.

Data Collector Module (left) and Sensor Array (right)

Technical Specifications

As certified by TÜV Süd :

Outer pipeline diameter (OD)[1]	3" to 16"
Maximum wall thickness (WT)[2]	10 mm
Pipeline depth (to its axis)	up to 2 m
Inspection current I_{cs}	16Aeff
Maximum pipeline range between two contact points	1.000 m
Productivity[3]	750 m
Depth resolution (uncertainty of depth of cover)	≤ 20 mm

Defect specification – Probability of detection (POD >96%) :

Length	50 mm
Width	50 mm
Metal loss	50% of WT
Defect detection (response threshold)[4]	> 20%of WT

1 Inspection of pipelines with outer diamter up to 42" is possible
2 Inspection of larger WT needs to be requested
3 Dependent on ground conditions (smoothness etc.)
4 Spirally welded pipes can be inspected

Detection of Metal Loss Features

The EMPIT inspection technique is capable to characterize defect sizes, expressed through different levels:

Detection Level 1 – the reference defect is classified through a minimum peak metal loss of 50 % and the dimensions 50 mm x 50 mm. The probability of detection for such a defect is at least 96 %. In this detection level, the pipeline has a depth of cover that is smaller than 1.5 m.
Detection below Level 1 - is used when a metal loss feature is in at least one coordinate smaller than the reference defect in this level. Detection of features starts if the metal loss is greater than 20 %.
Detection Level 2 – the reference defect is classified through a minimum peak metal loss of 50 % and the dimensions 150 mm x 150 mm. The probability of detection for such a defect is at least 96 %. In this detection level, the pipeline has a depth of cover that is between 1.5 m and 2 m.
Detection below Level 2 - is used when a metal loss feature is in at least one coordinate smaller than the reference defect in this level.

Example of Defect "Detection below Level 1"

Example of Defect "Detection below Level 2"

Detection of Coating Features

In addition to the faults survey, the intensity of the inspection current is monitored. At places, where the insulation (coating) of the pipeline is characterized by a defect, a small part of the inspection current leaks into the surrounding earth. As a result, the inspection current changes, which can be recognized from current plots.

The calculated inspection current values are plotted and presented in the graphic analysis, which is done for every inspected pipeline. A normalized scaling is used in current plots. As reference values for the normalization of the current, values at the current source output are used. Normally, the current value is changing monotonously along the pipeline due to the slight leakage of the pipeline coating. But in places where the coating is damaged the leakage is stronger and this produces a jump on the current plot, recognized by our system. Using this feature, coating damages will be detected. The threshold level for current leakage depends on coating kind, OD of the pipe and the soil conditions. For instance, the steepness of 0.3%/m can be used. Changes of the inspection current are indicated if the current jump feature is at least 1.5 m long.

Example of Coating Feature

02 // Inspection

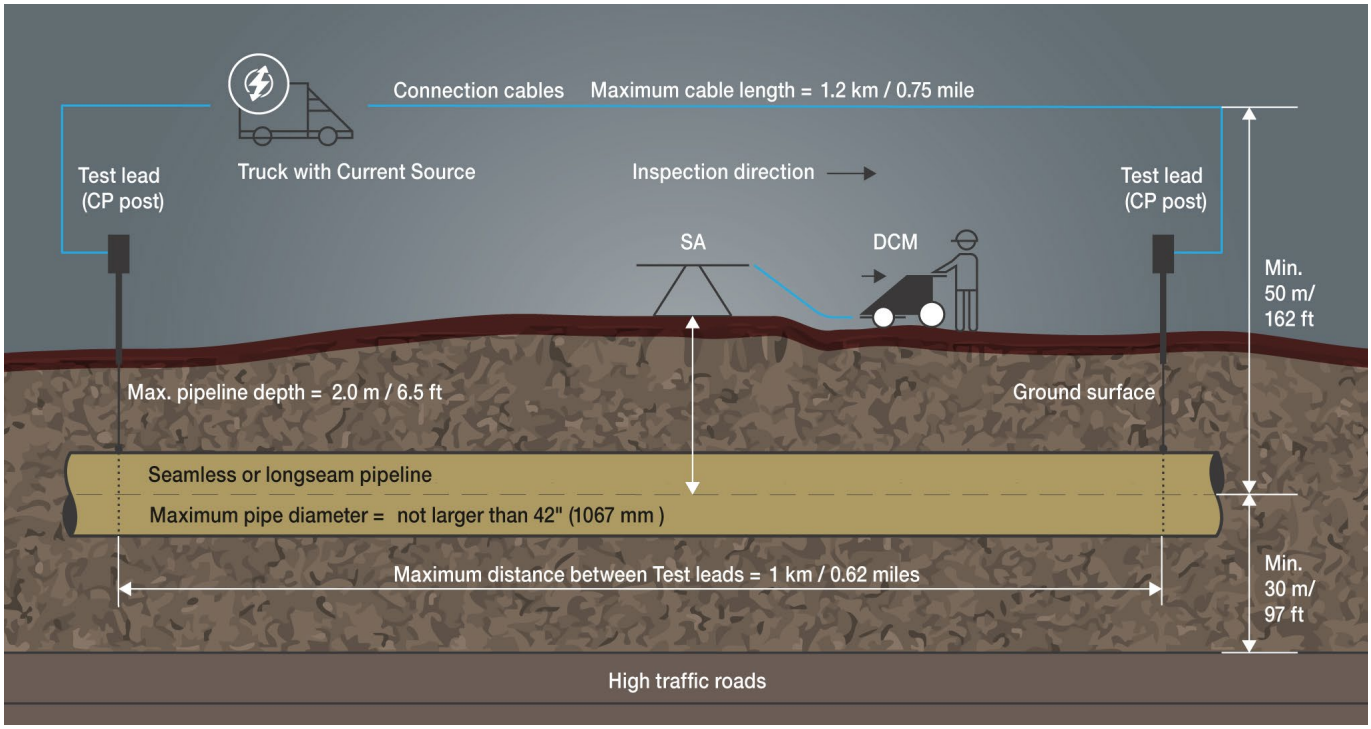
Inspection Run

- The graphic below shows the schematic visualisation of the setup for the inspection run - In order to create a measurable magnetic field, surrounding the pipeline, an A.C current is introduced into the pipeline. This can be either done through parts of the pipeline running above the ground (e.g. valves), through Cathodic-Protection-posts, or through dug holes. The two connection points should not lie more than 1,000 meters apart. After contacting and laying out the connection cable, a quick functional test is carried out. Then, the actual inspection begins. Starting point is one of the two connection points.

The monitor of the DCM shows a live-report of the depth of the pipeline, the exact position of the SA, the inspection current, and the positioning of the SA over the pipeline. The analysis of the magnetic field data and the calculation process take approx. 10 sec. During this time, the system is not moved. Afterwards, the SA and DCM will be moved 1 m further to the next inspection step. The storage of the data happens after every step. The assembly of the sensors in the SA allows a seamless capture and analysis of the magnetic field data and allows us to archive an average productivity of 750 m per day (depended on the surface over the pipeline).

Connection through CP-Post

Connection through dug hole



Schematic visualisation of EMPIT inspection Setup

03 // Evaluation

After the raw data are collected, the following steps are necessary in the evaluation process:

The first step of the post-processing is the reduction of external interferences on the magnetic field data. External interference can be caused by magnetic disturbances from the environment, from electric cables, or big metal objects – which sit close to the pipeline.

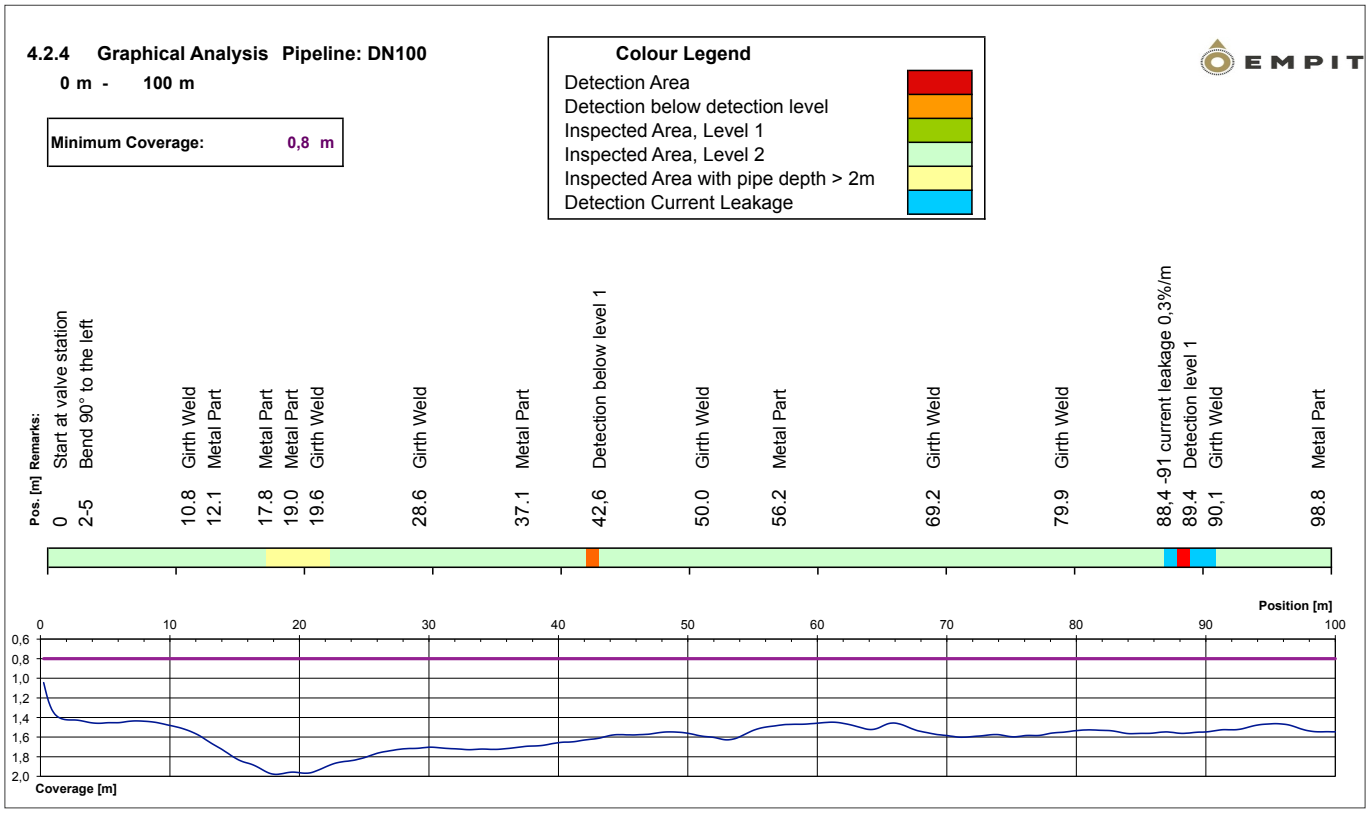
In the second step, the post-processed inspection data is evaluated. For the evaluation, a specially developed program is used. The program is able to calculate, filter, and display the magnetic field variation parameters in both, frequency, and spatial domains. A threshold level is used for a better defect recognition over interferences. Based on a clear recognition of the EMPIT reference defects, the threshold level is chosen. Afterwards, all information is summarized in graphical analysis spreadsheets.

The graphical analysis is based on magnetic field variation parameters. The bar, which is seen in the spreadsheet, schematically visualizes 100 m of the inspected pipeline. The bar is characterized by different colors – each has a different indication:

(1)	**dark green**	**Inspected area with Detection Level 1 (DOC > 1,5m)**
(2)	**light green**	**Inspected area with Detection Level 2 (DOC ≤ 1,5m ≥ 2m)**
(3)	**red**	**Metal loss feature**
(4)	**orange**	**Metal loss feature below detection level**
(5)	**blue**	**Coating defect**
(6)	**white**	**Not inspected or non-evaluable area**

Results 0 m – 100m: **(see graphic below)**

(1)	**42,6 m**	**Metal loss feature, “below Level 1”**
(2)	**89,4 m**	**Metel loss feature, “Level 1”**
(3)	**88,4 m – 91 m**	**Coating defect, 0,3 % / m**



Note: Besides information about features, the costumer will receive additional information about the pipeline, depending on the inspection conditions. This might be information about coating defects, girth welds, and metal parts. Metal parts are understood as built-in constructions or metallic objects buried close to the pipeline, e.g. crossing lines, valves, but also metal scrap. The magnetic field analysis only allows to make assumptions on types of metal objects.

Inspection of Depth of Cover (DOC)

The EMPIT-System measures the depth of cover for the full length of inspection every meter. The certified uncertainty of DOC-measurement is ≤ 20 mm. Exact values will be given in the graphical analysis. If not other stated by the customer the value for critical DOC, less than 0.8 m cover, will be highlighted in the final report.

Final Report

Our costumer receives a Final Report showing the features of the inspected section(s). The features are differentiated between metal loss features and coating features. Metal loss features are characterized in terms of size (mm) and metal loss (% of wall thickness). Also, critical depth of cover will be highlighted in the report.

Graphic Analysis

The Graphic Analysis, which is enclosed to every inspection report, serves to visualize the features of the pipeline. The Graphic Analysis will be done for every 100m of inspected pipeline. All features are directly linked to coordinates and to landmark points aboveground such as markers of the pipeline. This is becoming very handy during excavations of the features.

Reporting and Right of Way (ROW)

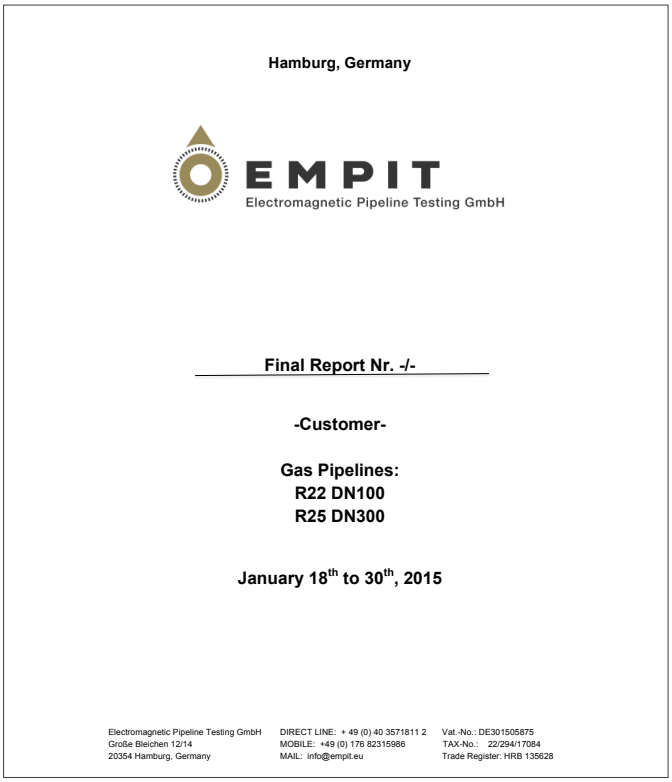
Enclosed to every 100 m spreadsheet, the customer receives photos, which have been taken during the survey. These pictures are shot every 50 m in the direction of inspection. The coordinate shown on a photo corresponds with the location of the Sensor Array over the pipeline. Therewith, the customer is able to evaluate the ROW-conditions.

Localization of Pipelines

The inspection technique finds the exact coordinates of the pipeline. While a usual pipe-finder holds 2 sensors, our system holds 24 sensors, which makes it to the best pipe-finder in the world. Consequently, it is possible for the pipeline operator to get exact information of the position of the pipeline.

EMPIT-Crew during inspection

Excavation of metal loss defect and coating defect



Hamburg, Germany

EMPIT
Electromagnetic Pipeline Testing GmbH

Final Report Nr. -/-

-Customer-

Gas Pipelines:
R22 DN100
R25 DN300

January 18th to 30th, 2015

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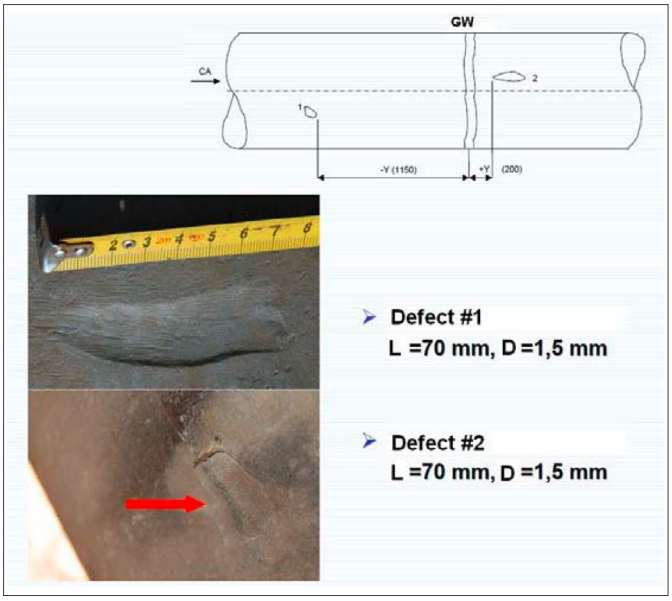
04 // References

EMPIT inspection projects were executed on gas, oil, brine and jet fuel pipelines, run by pipeline operators around the world. The outer diameter of inspected pipelines is so far spread from DN80 to DN1000. In order to give you a practical impression of our detection-abilities, results from a past inspection are presented below in detail:

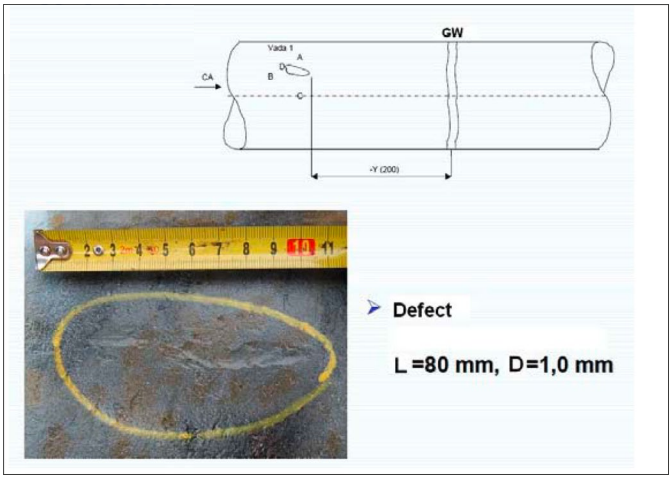
Defect 1

Type	**material loss, gouge (mill feature)**
Position	**115 cm in upstream direction from girth weld**
Axial length	**70 mm**
Circumferential width	**20 mm**
Max. material loss	**1.5 mm**
Measured Wall Thickness (WT)	**7.8 mm**
Calculated remaining WT	**6.3 mm**
Metall Loss	**19,2 %**



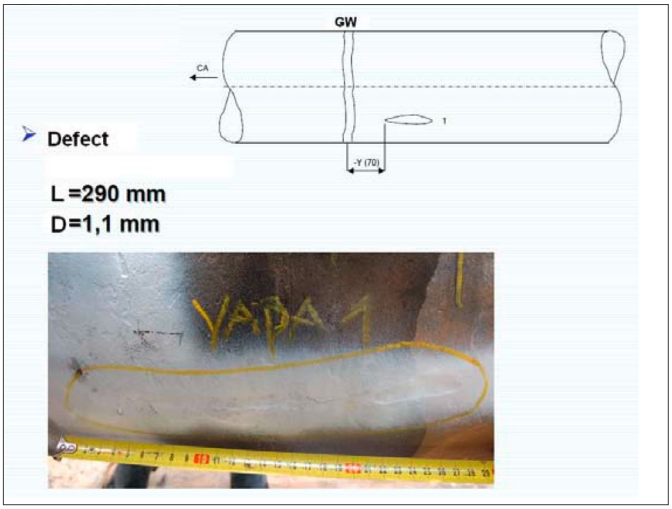
Defect 2

Type	**material loss, relocation**
Position	**20 cm in downstream direction from girth weld**
Axial length	**70 mm**
Circumferential width	**18 mm**
Max. material loss	**1.5 mm**
Measured WT	**7.8 mm**
Calculated remaining WT	**6.3 mm**
Metall Loss	



Defect 3

Type	**material loss, dent**
Position	**20 cm in upstream direction from girth weld**
Axial length	**80 mm**
Circumferential width	**10 mm**
Max. material loss	**1.0 mm**
Measured WT	**7.8 mm**
Calculated remaining WT	**6.8 m**



Defect 4

Type	**material loss**
Position	**7 cm in upstream direction from girth weld**
Axial length	**290 mm**
Circumferential width	**15 mm**
Max. material loss	**1.1 mm**
Measured WT	**7.8 mm**
Calculated remaining WT	**6.7 mm**

