

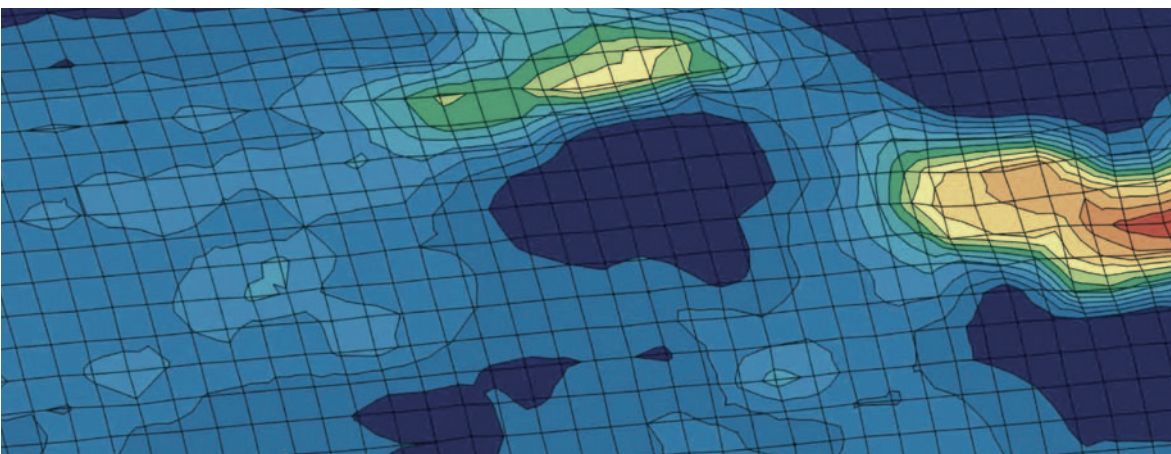
# INTEGRITY AND MATERIALS

February 2016

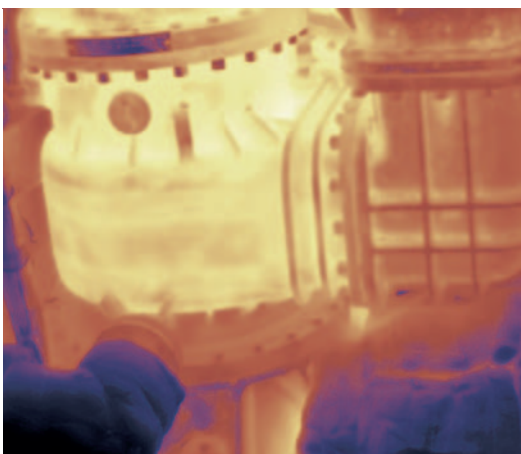
Tests | Calculations | Assessments

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**Left**  
Finite element calculation of a decrease in wall thickness



**Right**  
Thermographic analysis of a combustion chamber

Our answer to complex requirements

# Comprehensive services

**Transmission system operators face considerable challenges. On the one hand, they can only remain competitive if they operate their systems efficiently and tap any potential for optimisation to the full. On the other hand, they must maintain their high reliability and safety standards if they are to meet the requirements of applicable rules and regulations and changing market structures.**

**We offer a comprehensive service portfolio in this area, based on the experience and know-how gained from the operation of our pipeline network and the technical infrastructure available for this purpose.**

The safe and efficient construction and operation of gas transmission systems calls for complex decisions; there are a number of prerequisites that must be met. This applies to many areas such as material selection, component design and sizing, well-founded assessments of the condition of pipelines and facilities based on various test procedures, the determination of the repair and maintenance work required as well as quality assurance for materials, procedures and personnel.

The Materials Engineering department has a team of more than 25 highly qualified specialists to provide support in the following areas:

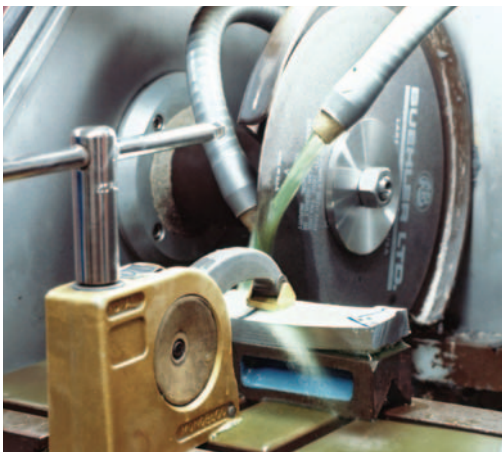
- Advice on safety, strength and material selection
- Assessment of the condition of pipelines and components
- Design calculations for components based on material properties and loading
- Measurements and safety assessments of strain, stress and vibrations on pipeline systems
- Destructive and non-destructive testing of materials, pipelines and plant components with a view to assessing their condition
- Static and dynamic pressure tests
- Assessment of high-pressure pipeline operating procedures

- Consultancy services in all these areas, including quality assurance and management
- Overall management of the integrity measures to be performed.

We are of course certified to DIN EN ISO 9001 (since 1996).

**Expert opinions**

In areas such as component design and sizing, test procedures and damage mechanisms, we have the know-how needed to provide expert opinions. Our team includes specialists recognised by DVGW (the German Association of the Gas and Water Industry) who are authorised to conduct hearings under Section 7 (2) of the German High-Pressure Gas Pipeline Regulation (GasHL-VO).



#### From left to right

Careful handling of materials is already essential during the specimen preparation stage (using a cutter in this case).

Advanced scanning electron microscope allows micro-scale inspection even of very large specimens.

Classical light microscopy is used for assessing microstructure conditions.

Qualitative and quantitative tests

## Knowing more about materials

4 | 5

**Material tests and analyses provide detailed qualitative and quantitative information on the microstructure of metals and other materials. Tests and analyses of these types are important for the development of material selection procedures, for in-process quality testing, as-received inspections, material identification and damage investigations. The results allow us to provide comprehensive, well-founded advice on material matters.**

#### Metallography

- Light microscopy on samples and component surfaces (macro-structure, micro-structure, granulometry, purity, porosity segregations and fracture surfaces)
- Macro and micro hardness testing

#### Scanning electron microscopy

- Direct imaging of solid surfaces (topography, fracture surfaces, corrosion products, wear, fibres such as asbestos)
- Qualitative and quantitative analysis on the microscopic scale (EDX analysis)

#### Spectrometry

- Determination of the chemical composition of a metal component (virtually non-destructive testing) for weldability and pre-heating assessment and identification of metallic materials

#### Surface measurements

- Roughness and profile measurements on components (assessment of surface quality, running properties and wear)

#### Thermography

Thermography is used for measuring temperature distributions or profiles over surfaces, allowing the investigation of large, inaccessible or moving components. The main applications of thermography include:

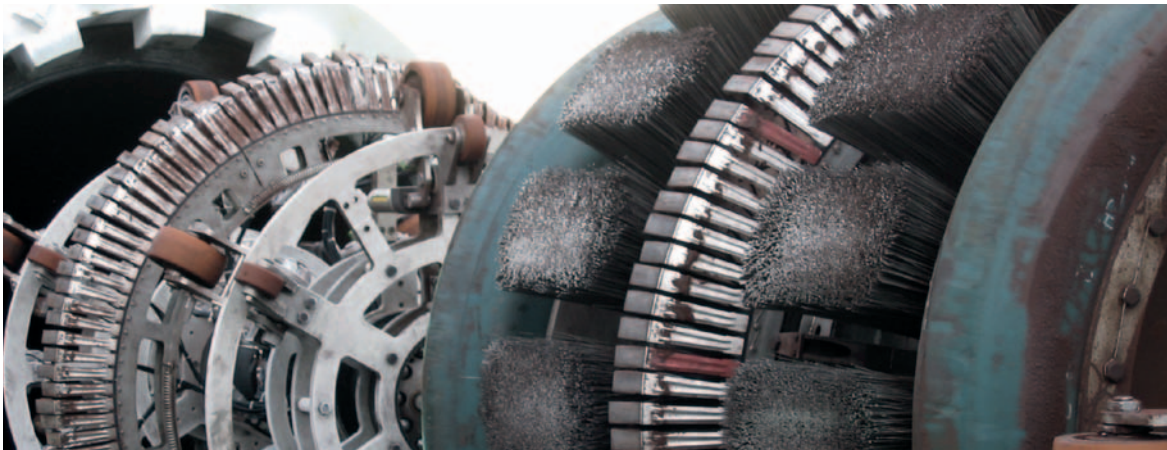
- Thermal optimisation of components, assemblies and systems
- Monitoring of start-up procedures at facilities such as compressor stations
- Determination of temperature distributions in machine assemblies with a view to ensuring compensation for any thermal expansion.

#### Failure investigations

Failure of components, such as fracture, cracking, corrosion or wear, may be caused by a number of very different factors. Our team includes experts from a variety of disciplines who can determine whether any damage is due to defects in component design, material selection, workmanship or a combination of different factors.



EDX provides a precise chemical analysis.



**Left**  
Magnetic flux leakage (MFL) pig  
for pipeline inspections



**Right**  
Temporary repair with  
repair clamp

Safe and reliable pipeline operation

## Integrity assessment

**Regular condition assessments of steel pipelines in transportation and distribution grids are essential when it comes to proving pipeline integrity and ensuring safe and reliable grid operation.**

Be it inline inspections involving the use of intelligent pigs or above-ground surveys based on alternative methods, the assessment of test results by groups of experts from different disciplines including integrity/material testing, corrosion protection, pipeline engineering and pipeline operation provides a thorough understanding of the structure's integrity and allows targeted and efficient planning of any maintenance work required.

Thanks to our years of experience in supervising and executing extensive inspection and assessment projects, we can draw on a unique combination of expertise and operating experience.

Our specialist know-how allows us to choose and apply the optimum inspection and evaluation methods.

### Pipeline inspection

- Project management and steering of pipeline inspection projects (pigging, etc.)

### Condition/integrity assessment

- Project management and steering of condition/integrity assessments
- Assessments according to national and international standards (DIN, DVGW, DNV, ASME etc.)
- Assessment from a material strength and corrosion protection perspective
- Assessment of pipe joints according to the certified PIA<sup>2</sup> method
- Assessment of individual defects

### Repairs/rehabilitation

Depending on the results of the condition assessment, it may be necessary for the operator to carry out maintenance or repair work or take safety precautions to maintain or restore pipeline integrity.

We can draw on an extensive catalogue of tried and tested repair methods and ways of making pipeline systems safe, and suggest technically and economically sensible actions.

### Independent expert hearing

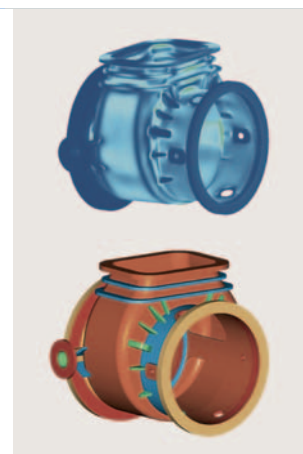
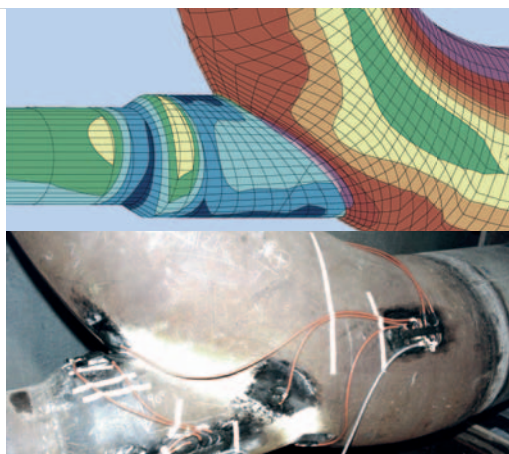
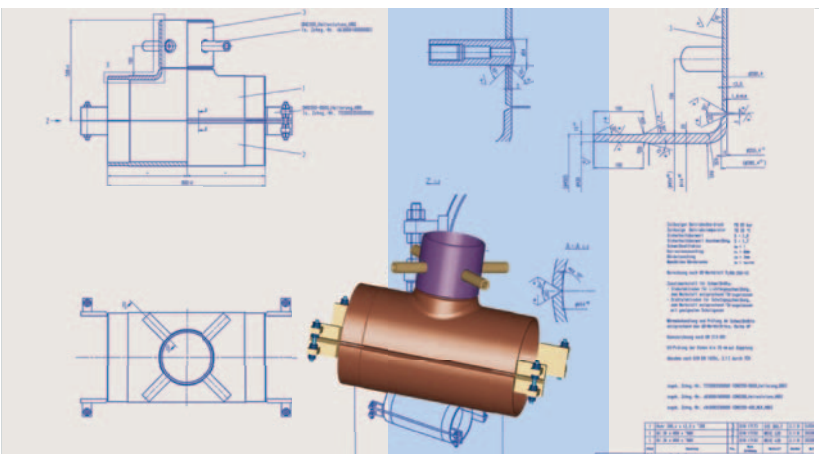
Where necessary to comply with applicable technical rules and regulations, integrity assessments and recommendations concerning the measures to be taken are recorded at official expert hearings.

### Open Grid Europe | The Gas Wheel

Open Grid Europe is one of the leading transmission system operators in Europe. We provide secure gas transmission in line with our customers' needs and are a partner you can rely on for all grid-related services – 24 hours a day, 7 days a week.

### The Facts

Our customers: more than 450 national and European TSOs, municipal utilities, industrial customers and gas traders | Our staff: around 1,650 across Germany | Our transmission system: around 12,000 km long, with 30 compressor stations, 100 machine units. 17 border crossing points. Around 1,100 entry points, 679 bn kWh exit volume in 2014. Around 137 mn kW peak load in 2014.



**From left to right**  
 Stopple tee with special flange:  
 3-D model and design drawing

Hot bend with axial restraint: Strain gauge  
 measurement and simulation

Combustion manifold design based on  
 I-DEAS calculations

Highly specialised software

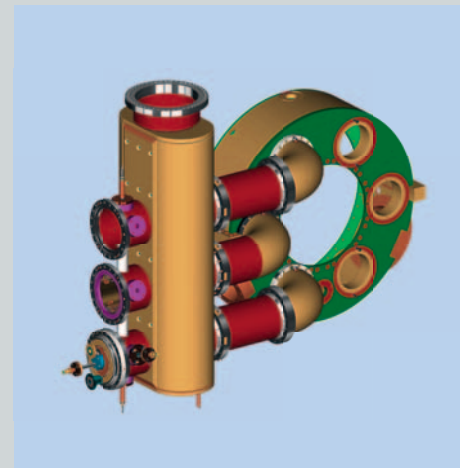
# Maximising safety and availability through simulation and design

**Numeric simulation is a highly versatile technique for effectively assessing the safety of pipeline components. We offer a broad portfolio of services in this field, especially complex calculations of the static and dynamic behaviour of pressure-containing components. We use highly specialised calculation and design software including ABAQUS, I-DEAS, DIMy, ROHR2, CRACKWISE 3, FREEFORM-MODELER and Geomagic.**

**Finite element analysis**  
 Finite element analysis methods can be used for modelling stress, strain and deformation at any point on a complex pipeline component. These methods are very useful for components which cannot be designed in accordance with conventional standards or call for complex safety studies as well as pipeline sections affected by corrosion or mechanical damage.

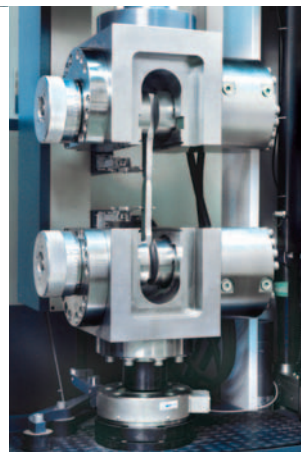
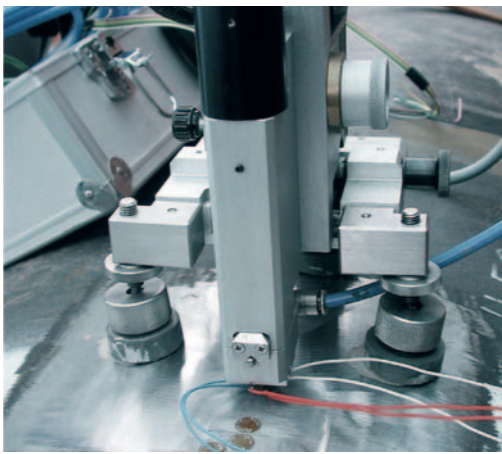
Entire pipeline systems can also be modelled, for example to assess the effects of compressor pulsations or possible damage to pipelines subject to movement in mining subsidence areas or on steep slopes.

**Design of pipeline and plant components**  
 Based on applicable technical codes and standards, we design pressure-bearing parts required for the maintenance, repair and optimisation of pipeline and plant components. Sophisticated products are often needed at short notice but are not readily available on the market. We use 3-D CAD systems (I-DEAS/NX) and TÜV-approved calculation programs (DIMy, ROHR2) to provide the required proof of integrity. Components manufactured by contractors undergo safety and quality testing as well as acceptance procedures at Open Grid Europe.



3-D model of a combustion chamber manifold calculated using I-DEAS

- Design of pipeline and plant components**
- Flared and welded tees
  - Special flanges, caps
  - Stopple and hot tapping components
  - Pressure vessels, pig traps
  - Valve assemblies, metering systems
  - Reducers, split sleeves
- Design optimisation for compressor systems and technical gas applications**
- Combustion chamber manifolds on compressors (DLN optimisation)
  - Recuperators, expansion joint lines
  - Exhaust gas headers
  - Heat exchangers, filters, separators
  - Engine components
  - Natural gas burners



**From left to right**  
 Residual stress measurements by hole drilling method  
 Tensile test on pipe material  
 Laser-scan test on pipe joint  
 Bent pipe segment with special joint under internal cyclic pressure in burst test pit

Finding the weakest link

## Material and component assessment

**In practice, we often need to assess the condition of a pipeline and other gas transmission system components to identify weaknesses and to determine whether a component or system meets the applicable safety requirements. Various methods are available for this purpose. Destructive testing and the inspection of entire components allows us to determine whether materials and parts have the specified properties and meet the requirements for operation in a specific environment.**

### Destructive tests

- Tensile tests with forces up to 600 kN (60 t)
- Bending tests with forces up to 200 kN (20 t)
- Charpy impact tests with energy up to 300 Joule

### Hydrostatic tests

- On test vessels and pipeline components up to DN 1200 with lengths up to 6 m
- Strength tests or burst tests up to 1,400 bar
- Cyclic pressure tests up to 700 bar
- With strain gauges if required

### Combined stress tests

- Internal pressure and 4-point bending, static and dynamic

### Vibration measurements

- For pile-driving, blasting and soil compaction work
- Including safety assessments
- Vibration measurements with two 3-component sensors

### Strain measurements

- For monitoring additional stress on buried pipelines
- In the case of mining subsidence, unstable soil conditions, traffic loads, additional cover, raising of pipelines, etc.
- Installation of strain gauges as required (including permanent measurement stations upon request)
- Performance of measurements at regular intervals (including automatic data polling)
- Calculations and documentation of results
- Residual stress measurements based on hole drilling method

### Experimental stress analysis

- Laboratory measurements on pipeline components using strain gauges
- Failure investigations
- Inspection of special structures

- Measurement of component geometry using non-contact 3-D surveying systems
- Additional calculations by finite element analysis, where required

### Consultancy services for component design, manufacture and standardisation

With comprehensive experience in design work, component inspection, destructive and non-destructive testing and damage investigation, we are in a position to provide practically oriented consultancy services for component design and construction preparations for high-pressure gas pipelines and facilities.

We also offer support for internal standardisation work, the drafting of specifications as well as quality assurance (for components such as fittings, split sleeves, isolating joints, etc.).

### Your contact

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