

July 2016

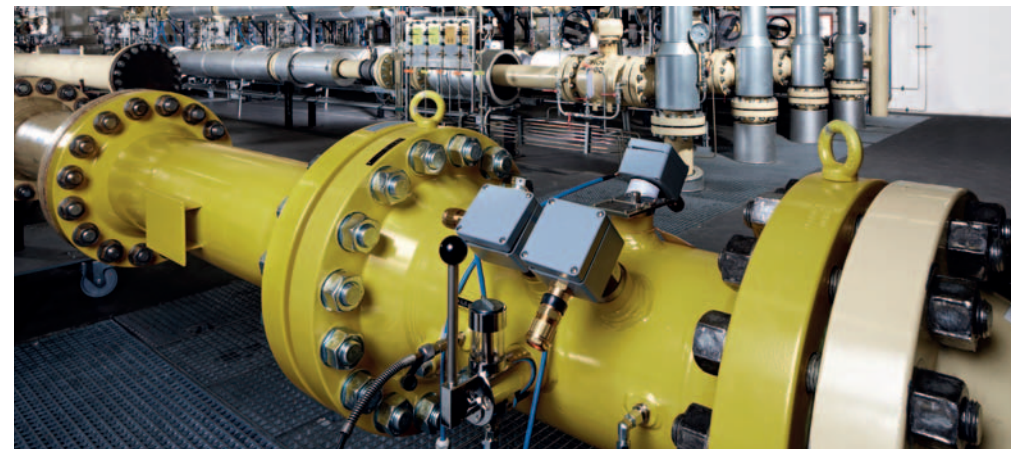
High-pressure gas meter test facility

Highly accurate calibration and verification of gas meters

Location of the national standard for flow measurement with natural gas

Vier Gas Services GmbH & Co. KG
Halterner Str. 125 | 46284 Dorsten | Germany
T +49 2362 93 8678 | F +49 2362 93 8702
info@pigsar.de
www.pigsar.de





Home of high-pressure flow measurement with natural gas in Germany

Welcome to pigsar™!

For more than two decades, pigsar™ has been cooperating directly with the German Federal Institute of Physics and Metrology (PTB) to ensure that flow measurement in European gas trading is conducted at a stable level with the highest measuring accuracy.

Over this period, a large proportion of the gas meters installed in the European natural gas transmission system have been calibrated at pigsar™. Together with the national standards of the PTB, pigsar™ forms the basis for high-pressure gas flow measurement in Germany and many other countries and is thus an indispensable part of the German and international gas industry.



pigsar™ is part of Vier Gas Services GmbH & Co. KG, the sole shareholder of Vier Gas Transport GmbH, which in turn holds 100% of the shares in Open Grid Europe GmbH. The name pigsar™ is a registered trademark.



The German Federal Institute of Physics and Metrology (Physikalisch-Technische Bundesanstalt, PTB), the national metrology institute, is Germany's supreme scientific and technical authority within the portfolio of the Federal Ministry of Economic Affairs and Energy (BMWi).



As part of the European gas network, Open Grid Europe GmbH markets and operates one of the biggest gas transmission systems in Germany. It is around 12,000 km long, has 30 compressor stations, 100 compressor units, 17 border crossing points and around 1,100 exit points. In 2014 the total exit volume was 679 billion kWh.

Setting standards for over 20 years

pigsar™ chronology

2 | 3

1993

pigsar™ (the German acronym means: "Prüfinstitut für Gaszähler, ein Serviceangebot der Ruhrgas AG" – testing institute for gas meters, a service by Ruhrgas AG) starts operating officially as a state-approved testing facility.

1996

Accreditation of pigsar™ by the German Calibration Service (DKD, now DAkkS) in accordance with ISO/IEC 17025.

1999

Contractual agreement between PTB and Ruhrgas AG for the operation by pigsar™ of the National Standard of Germany for the unit of volume "high-pressure natural gas" (original cubic metre).

Agreement between PTB and its Dutch counterpart NMI (in collaboration with pigsar™) on the harmonisation of the volumetric measurement of high-pressure natural gas in Germany and the Netherlands, represent-

ing a fundamental contribution to improving cross-border natural gas trading.

2003

Installation of the National Standard and other PTB equipment at a new pigsar™ test facility.

2004

French high-pressure natural gas measurement joins the 1999 harmonisation.

2011

10,000th calibration certificate issued.

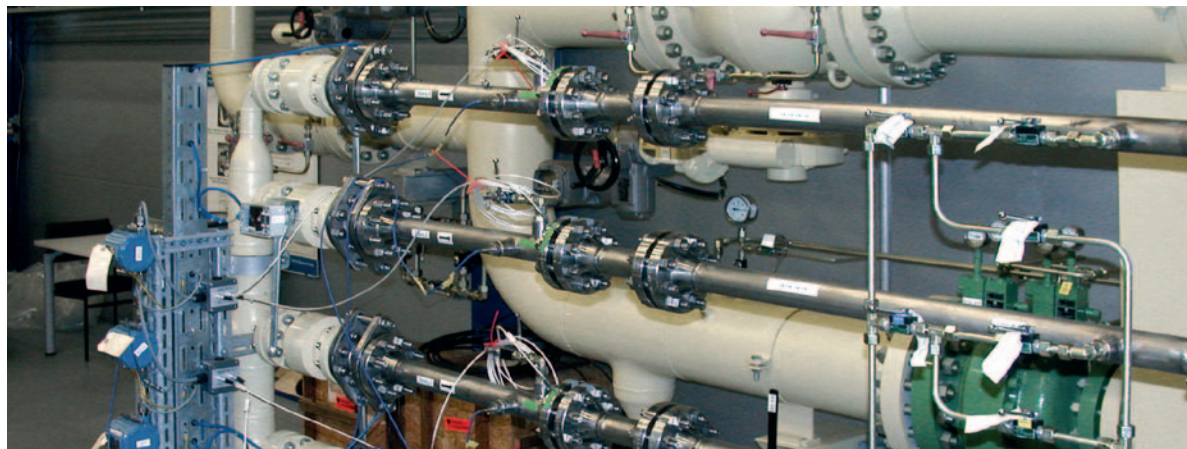
2013

Danish high-pressure natural gas measurement joins harmonisation agreement.

Vier Gas Services GmbH & Co. KG becomes the new owner of pigsar™.

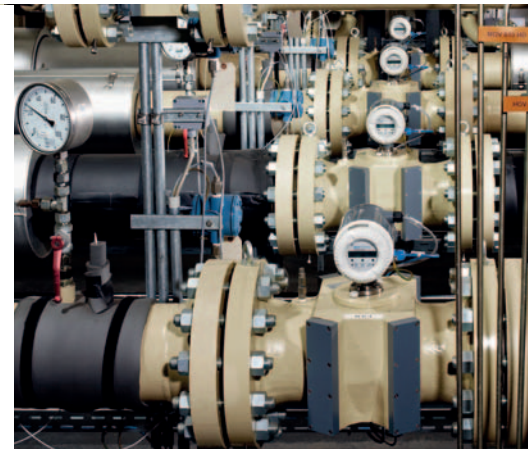
2014

pigsar™ accreditation also extended to mass flow meters and differential pressure metering processes (e.g. orifice plate meter runs).



Precision means reliability

The scatter plot displays the deviation transfer meter values (y-axis, ranging from -0.5 to 1.0) against the Reynolds number (x-axis, logarithmic scale from 1E+05 to 1E+07). The data points are categorized by year: 2003 (brown circles), 2005 (blue circles), 2007 (orange circles), 2011 (green circles), 2013 (light blue circles), and 2015 (dark blue circles). The plot shows a general upward trend in deviation transfer meter values as the Reynolds number increases, with data points clustered around a horizontal line at 0% deviation.



Our test facility in Dorsten

Test facility configuration

pigsar™ is connected to the gas transmission pipeline system of Open Grid Europe GmbH. The local infrastructure at the Dorsten site allows pigsar™ to be operated in a bypass-configuration parallel to the pressure regulating stations.

To prepare for the test, the natural gas is first cleaned in a cartridge filter and then preheated. During the test, the preheater also controls the temperature. Between the preheater and the pressure regulator two safety shut-off valves protect the test facility against excess pressure. Downstream of the pressure regulator the gas flow is divided into a gas stream which is used for measurement and an internal bypass stream. Flow control is executed further downstream in both gas flows, shortly before they join up again ahead of the station outlet.

The piping configuration was optimised so that gas volume between the working standards and the test meters is reduced to the minimum, which minimises the line-pack effect.

The gas meters to be calibrated, including upstream and downstream straight lengths provided by the customer, can be installed on a total of six test meter runs with a length of up to 22m. The PTB test installations (piston prover (RPS), optical standard, transfer meters, sonic nozzles) are permanently integrated into the pigsar™ piping system.

Key technical details of test facility

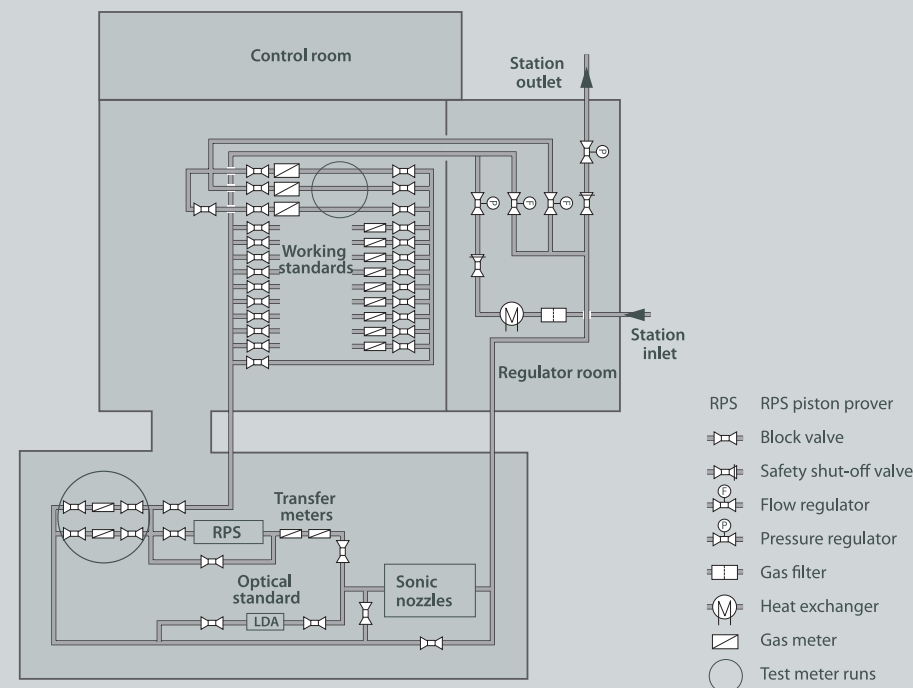
Test medium: Natural gas

Flow range of facility:

Volumetric flow: 3 to 6,500 m³/h

Mass flow: 40 to 285,000 kg/h

Pressure range: 1.6 to 5.0 MPa



Meters to be tested: all volumetric and mass flow meters as well as differential pressure flow devices (orifice meters, Venturi meters etc.) sized up to DN 500

Working standards: 9 parallel meter runs (turbine flow meters, 4 x G 1000, 4 x G 250 and 1 x G 160)

Test meter runs: 6 runs up to 22 m (longer sections can be provided on request)

Measurement uncertainty (dependent on flow, extended measurement uncertainty):

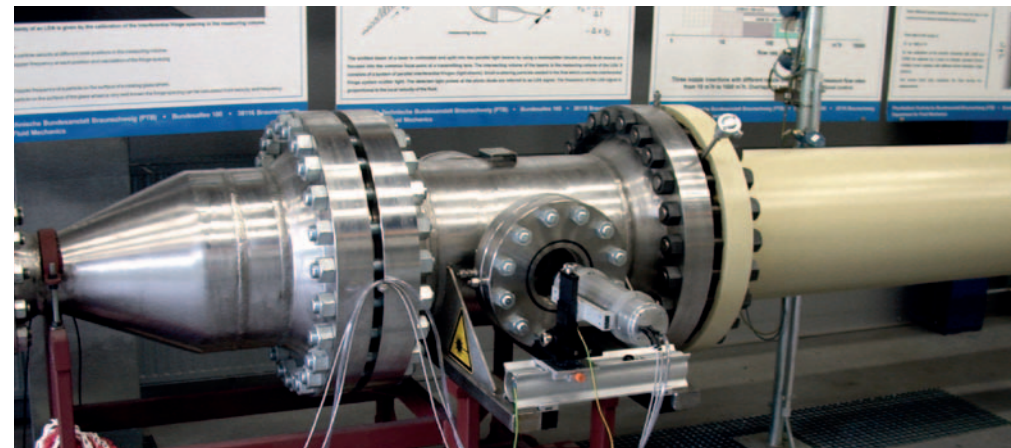
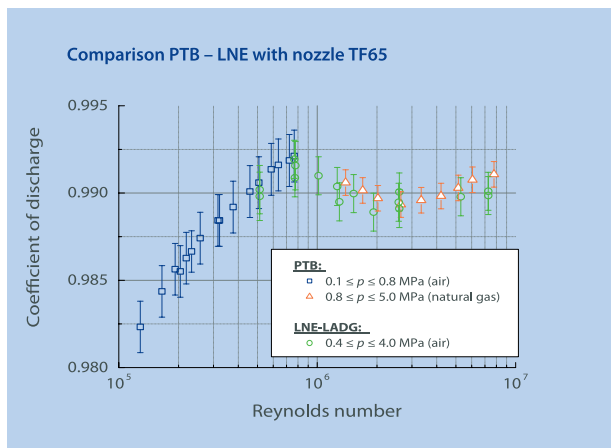
Volumetric flow meters:

$U_{95} \% = 0.13$ to 0.16% for $Q \geq 8 \text{ m}^3/\text{h}$

$U_{95} \% = 0.16$ to 0.26% for $Q < 8 \text{ m}^3/\text{h}$

Mass flow meters:

$U_{95} \% = 0.16$ to 0.28%



Maximum accuracy from the very start

The national standards

8 | 9

The piston prover

The calibration of the pigsar™ working standards is based on the most accurate volumetric measuring device for high-pressure natural gas in Germany: the RPS, or piston prover. The piston prover represents the primary standard (the “original cubic metre” for high-pressure natural gas) not just for the pigsar™ test facility but – as the national standard of the PTB – for the whole of Germany.

Installed directly downstream of the piston prover are two secondary standards, turbine gas meters sized DN100 G250, which are calibrated directly against the piston prover. The pigsar™ working standards are calibrated on the basis of these secondary standards. The extended measurement uncertainty of the piston prover is less than 0.01%; the measurement uncertainty of the secondary standards is around 0.1%. Thanks to optimum integration of the piston prover and secondary standards into the pigsar™ station configuration, they can be connected at any time with

the working standards of the pigsar™ facility. pigsar™ is completely recalibrated every three years, while a check (calibration) of the working standards is undertaken every month.

As the piston prover is operated at an absolute pressure of 5.5 MPa and a maximum volumetric flow of 480 m³/h, the calibration chain of the pigsar™, i.e. the traceability to SI base units, is extremely short.



Sonic nozzles

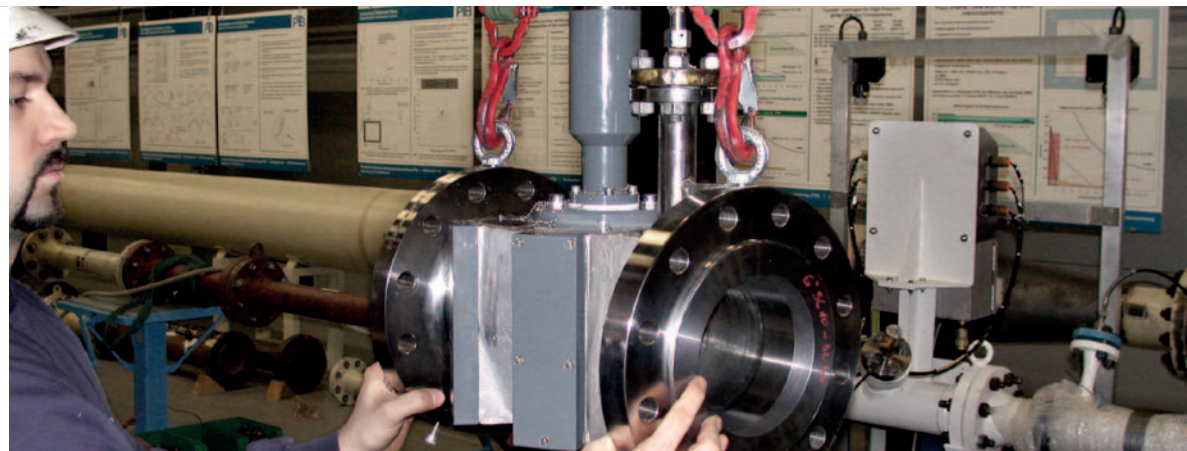
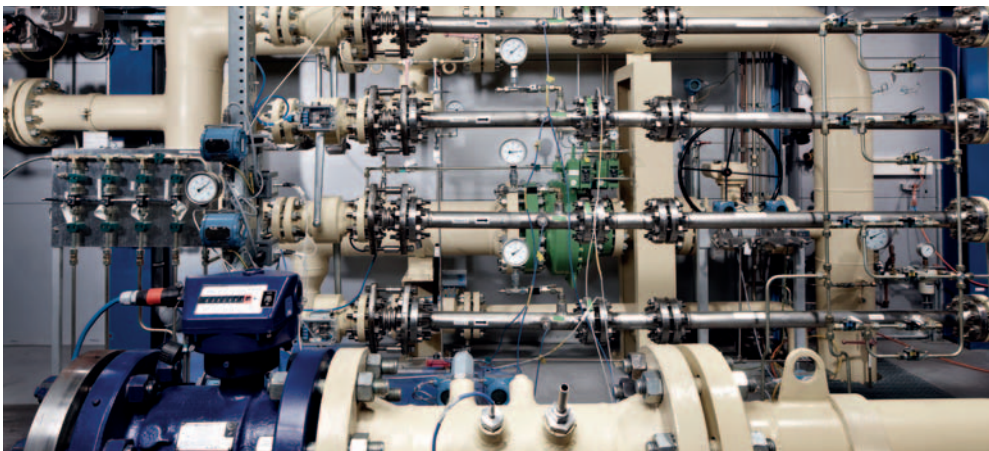
Sonic nozzles are flow elements used at pigsar™ both to stabilise the flow through the standard and as flow measuring devices. The measuring principle is that the exact velocity of sound is reached in the narrowest flow cross-section above a specific pressure ratio between the inlet and outlet of the nozzle. This can be calculated using the respective operating parameters to obtain the volumetric flow by multiplying the velocity by the cross-sectional area. Every nozzle is calibrated individually either against the piston prover or the secondary standard.

The sonic nozzles can be used to calibrate other test facilities and to compare test facilities. The diagram above illustrates this kind of comparison with two other test facilities.

Optical primary standard

To further improve the calibration chain, the PTB developed a new technology at pigsar™ based on Laser Doppler Anemometry (LDA).

As an addition to the piston prover, a second, independent primary standard was configured for pigsar™ which can also be traced back directly to the SI units metre and second. The operating principle of this optical primary standard is as follows: downstream of an undisturbed flow section the gas flow is accelerated in a subsonic nozzle. The flow velocity is measured in the nozzle exit using LDA. The flow velocity and nozzle exit area give the volumetric flow. The new standard is a prototype with a maximum volumetric flow of 1,600 m³/h. In France work is currently being carried out on a refinement for LNG applications. Details of the optical standard are available from www.iopscience.iop.org under reference No. 10.1088/0026-1394/51/5/459.



EUREGA – European Reference for Gas Metering

The harmonised reference level

Under the Dordrecht agreement of 2 June 1999, the national traceability chains for high-pressure natural gas in Germany and the Netherlands were harmonised.

The French LNE (Laboratoire national de métrologie et d'essais) joined the agreement in 2004, resulting in a harmonised joint reference standard for Germany, the Netherlands and France. Since 2013 Denmark has been the fourth partner to the agreement via its FORCE test facilities, so that the harmonised reference standard now comprises all four independent calibration chains in Europe for high-pressure natural gas measurement. The national metrology authorities concluded the necessary agreements to achieve this in a Memorandum of Understanding. The new reference level will now be called **EUREGA** – European Reference for Gas Metering

The harmonisation is based on the metrological comparison of the four participating test facilities using transfer meters sized DN100–DN400. These comparisons are carried out on an ongoing basis.

As the starting point for the German traceability chain, pigsar™ incorporates this common, harmonised reference level and passes on only this standard to all other testing facilities and customer gas meters.



Our range of services

10 | 11

- **Calibration of meters and complete meter runs** (turbine flow meters, ultrasonic flow meters, vortex flow meters, Coriolis meters, orifice meters, Venturi nozzles, sonic nozzles etc.) at $p = 1.6$ to 5.0 MPa, $Q_b = 3$ to $6,500$ m³/h
- **Calibration (by “derivation”) of other test facilities** (in collaboration with the PTB), either through direct calibration of working standards or via transfer meters
- **Special calibrations** of turbine flow meters, rotary piston flow meters and sonic nozzles directly against the primary standard high-pressure piston prover in the flow range $Q_b = 3$ to 480 m³/h and at pressures of $p = 0.8$ to 5.5 MPa. The extended measurement uncertainty for these calibrations is around $U_{95\%} = 0.1\%$
- In collaboration with the PTB and based on additional investigations (e.g. calibration with atmospheric air), **certificates for other pressure ranges** (0.1 to more than 10 MPa and other gases (air, N₂, CO₂) can be provided
- **Static (zero flow) testing (dry calibration)** of ultrasonic flow meters with natural gas up to 25 MPa

For further information please visit our website: www.pigsar.de,

which includes an extensive download area to assist you with submitting your inquiry to us.

Contacts:

Dr. Detlef Vieth • T +49 2362 93 8678 • info@pigsar.de

Christoph Thiede • T +49 2362 93 8682 • info@pigsar.de