Hobré "HIGAS", a Portable Natural Gas Quality Meter

Wobbe Index Analyzer

REPORT

Project report

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Danish Gas Technology Centre • Dr. Neergaards Vej 5B • DK-2970 Hørsholm • Tlf. +45 2016 9600 • www.dgc.dk • dgc@dgc.dk

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Wobbe Index Analyzer

Jan de Wit, Bjørn K. Eliasen

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Table of Contents Page

Enclosures

1 Introduction

Hobré has developed a portable and lower-price version of their stationary Wobbe index analyzer equipment. This unit is called Hóbre HIGAS (Portable) Gas Quality Meter.

An early version of this portable unit was at the end of April 2015 shipped to Danish Gas Technology Centre (DGC) for a third-party test in the laboratory and in the field. The unit is shown in Figure 1.

Figure 1 The Hobré Wobbe test unit, the touch display and the sample connections

In Europe, Denmark has de facto the largest changes in Wobbe index in the natural gas grid these years as a result of import/export of natural gas. High-end Wobbe numbers are seen when North Sea gas is in the grid (up to approx. 55.7 MJ/Nm^3) and low-end Wobbe numbers are seen during import situations from/via Germany, the actual number depending on the origin of the gas imported. The current national legislation allows import with Wobbe index down to approx. 50.8 MJ/Nm^3 during normal operation situations.

This note provides a short introduction to the HIGAS Wobbe meter and the tests carried out by DGC.

The manufacturer’s specification for the equipment is attached as Enclosure 1.

The DGC work carried out was financed by the Danish gas distribution companies DONG Energy, HMN, NGF Nature Energy and HOFOR through the Gas Companies' Technical Committee co-operation.

2 The Wobbe Index

The Wobbe Index is a calculated number on the basis of the higher heating value (Higher Calorific Value) divided by the square root of relative density (gas compared to atmospheric air):

$$WI = \frac{H_s}{\sqrt{d}}$$

Where:

W: Wobbe Index

H_s: Heating value, higher

d: Gas density relative to air density

If two different gasses have the same Wobbe Index, the firing rate (kW, MW etc.) will be the same when using the same nozzle gas pressure.

The Danish Gas Regulations Section C-12 defines the permitted Wobbe range for natural gas (2H) delivered to end users as 50.76 – 55.8 MJ/Nm^3 during normal supply situations. During abnormal supply situations, natural gas with Wobbe index down to 50.04 MJ/Nm^3 is permitted.

3 The HIGAS unit

The HIGAS unit is produced by the Dutch manufacturer Hobré Analyzer Solutions. For many years, this company has supplied stationary Wobbe measuring equipment and gas mixer solutions to the Dutch gas distribution system.

The HIGAS unit we tested is a new development. It is a portable version at a lower price than the versions used in the stationary gas mixing stations. The measuring principle is the same, the price is lower, but the measuring accuracy is not as precise as in the high-cost versions.

The unit is meant for periodic gas system analysis, for use when adjusting settings for new appliances, or as a feed-forward signal for furnace control at gas quality sensitive industrial processes.

The unit comes in a carry bag; it includes a battery (3 kg, rechargeable) which allows operation without power connection. The unit forwarded to DGC is designed for a Wobbe Index span from 40 to 60 MJ/Nm^3. Additional HIGAS equipment specifications is attached as Enclosure 1 to this report.

The unit includes a display showing the following key numbers:

- Wobbe Index for the sample gas.
- CARI: Combustion Air Requirement Index, depends on the actual sample.
- O_2 %, remaining O_2 in sample after passage of the test oven in the Wobbe meter.
- Sample gas pressure.

The heating value (calorific value) and specific gravity are optional readings.

The measuring principle is a controlled combustion of the sample gas in a heated oven in the instrument with subsequent residual oxygen content measurement in this flue gas (Zirkonium Oxide cell) used for Wobbe Index determination. Heating of the internal oven is fast, takes approx. 5 -10

minutes, and the Wobbe Index etc. can be read in less than 15 seconds according to the manufacturer's specification.

Calibration is generally made as one-point calibration (G-20 gas). Two-point calibration is an option. It is recommended to do weekly calibration with the unit in its current development state; longer intervals might be possible later.

The unit supplied has no memory or internal logging. There is a touch screen with on-line readout and a 4- 20 mA signal output for external data logging.

The tested preliminary unit weighs approx. 15 kg including the battery which accounts for approx. 3 kg according to manufacturer’s information.

4 Tests in laboratory

DGC performed tests with a preliminary version of the HIGAS Analyzer. The unit supplied to DGC has the specifications given in Enclosure 1. The weight is higher than stated in enclosure 1 and the unit supplied is not wall mounted.

DGC first performed tests with three certified gasses in the high and low Wobbe regime using grid supplied natural gas.These tests were made during the handover tests (one-day activity) followed by one week testing in the DGC laboratory. The one-week test was made with the appliance in continuous operation at grid supplied natural gas, “interrupted” by short-time tests with the certified gasses connected to the sample input to the appliance.

The composition of the test gasses used can be seen in Table 1.

Table 1 The gasses used for the initial tests of the HIGAS analyzer during tests at DGC, the numbers are based on certificates, GC analysis and calculations.

Component	**Unit**	**G-20** [1)]	**High Wobbe**	**Low Wobbe**	**N-gas** [2)]
Methane	mol %	100	84.908	83.021	88,67
Ethane	mol %	0	0	0	6,12
Propane	mol %	0	13.102	2.002	2,46
i-Butane	mol %	0	0	0	0,40
n-Butane	mol %	0	0	0	0,59
i-Pentane	mol %	0	0	0	0,14
n-Pentane	mol %	0	0	0	0,09
Hexan +	mol %	0	0	0	0,05
Nitrogen	mol %	0	1.990	14.975	0,32
Carbon dioxide	mol %	0	0	0	1,18
Heating value	*MJ/Nm^3*	*39,83*	*46,89*	*35,05*	*43,79*
Density	*kg/Nm^3*	*0,718*	*0,894*	*0,823*	*0,83*
Air requirement, theoretical minimum	*Nm^3/Nm^3*	*9,65*	*11,37*	*8,50*	*10,62*
Wobbe index	*MJ/Nm^3*	*53,47*	*56,39*	*43,94*	*54,66*

[1)] *Class 4.5*

[2)] *Example of an natural gas analysis*

The results of the tests can be seen in Figure 2 on the following page.

Figure 2 The DGC lab tests with the Hobré Wobbe meter. Natural gas, G-20 and two certified gas mixtures (high and low Wobbe) was used. The instrument was calibrated with G-20 at the calibration port prior to this series of measurements. When using the low-Wobbe gas, the sampling pressure was reduced from approx. 100 to 25 mbar as shown. The readout signal (Wobbe Index) was not significantly affected by this.

Please find further comments on the findings in the report conclusion. The Lab tests was carried out by DGC employee Brian Ildved and Leo van Gruijthuijsen

5 Field testing, upgraded biogas (17/7 2015)

It was decided to make a field test on upgraded biogas (biomethane) at the Holsted plant under commissioning. At this plant, sulphur is first removed and CO_2 is taken out via water scrubbers. The biomethane (4 bar) is injected into the natural gas grid at 4 or 40 bar.

The Hobré HIGAS instrument had been calibrated in the DGC laboratory prior to the travel to Holsted. This calibration was a one-point calibration.

A low pressure sample point at the Holsted Plant was used. At this sample point sulphur has been removed from the gas and no odorant is in the gas. The sample pipe was flushed and Teflon bag samples were taken for analysis at the DGC laboratory. The test was performed the 17.07.2015 by the Bjørn K. Eliasen, DGC.

The Hobré instrument was installed and a gas sample pressure of 100 mbar was established. After heating up in less than 5 minutes a Wobbe number read-out of 53,0 MJ/Nm^{3}could be seen for the biomethane. The on-site GC´s owned by DONG Energy showed a Wobbe number of 52,02 MJ/Nm^3.

5.1 Test with low-Wobbe import gas (import 06.08.2015)

From April to July 2015, Denmark was net-exporter of natural gas and the gas flow southward at the border crossing between Denmark and Germany. No longer periods with import of low-Wobbe gas from Germany occurred to enable field testing on such low-Wobbe gas.

From August 5 to 6 suddenly a short unplanned period with import of approx. 200.000 Nm^3/h low-Wobbe gas occurred. A DGC employee took gas samples of this import gas as close as possibly to the border entry point. Gas samples were taken in Teflon bags and in a pressurized bottle of 3.5 bar. The sample point was at an industrial consumer with a relatively high consumption less than 5 km from the border station. At the time of the sample taking, import gas was measured in the 80 bar transmission system at a metering and pressure reduction station Terkelsbøl more than 25 km north. The sample point was less than 5 km from the border entry point “Frøslev”

where low-Wobbe gas was predicted from 05:00 in the morning according to the Energinet.dk website.

Shortly after the sample taking shortly after noon 06.08.2015, the import gas flow was reduced and finally stopped, and export started again.

The gas samples were brought to the DGC laboratory and analysed by the official DGC gas chromatograph (GC). The result of the gas analyses of the import gas by the DGC GC can be seen in Table 2.

Table 2 The DGC GC analysis results and calculations of the import natural gas analysis of samples taken 06.08.2015

Component	**Unit**	**"Gas Sample" (06.08.2015, Kruså)[1)]**	**DK-N-gas [2)]**
Methane	mol %	88,75	88,67
Ethane	mol %	5,98	6,12
Propane	mol %	2,46	2,46
i-Butane	mol %	0,41	0,40
n-Butane	mol %	0,574	0,59
i-Pentane	mol %	0,142	0,14
n-Pentane	mol %	0.082	0,09
Hexan +	mol %	0,068	0,05
Nitrogen	mol %	0,351	0,32
Carbon dioxide	mol %	1,18	1,18
Heating value	*MJ/Nm^3*	*43,75*	*43,79*
Density	*kg/Nm^3*	*0,83*	*0,83*
Wobbe index	*MJ/Nm^3*	*54,65*	*54,66*

[1)] *Import gas sample taken approx. 12:30 06.08.2015 at a large industrial customer in Kruså*

[2)] *Example of a usual Danish natural gas analysis, from table 1*

The above DGC chromatograph testing (Table 2) shows that the gas samples taken are not the expected low-Wobbe import gas.

Tests were made with the Hobré HIGAS instrument. After one-point methane calibration a Wobbe Index of 55,3 MJ/Nm^3 was measured for the gas sample taken in Kruså.

Below the HIGAS display readings can be seen.

5.2 Field testing, Polish natural gas

DCG has been provided a Polish gas sample from an industrial site in the Polish natural gas system available. The gas was analysed in the official DGC GC, see the results in Table 3.

The results show a gas sample similar to the low-Wobbe import gasses imported to Denmark from time to time.

Table 3 The DGC GC analysis results and calculations for the Polish gas sample tested

Component	Unit	Gas Sample "Poland"
Methane	mol %	94,3
Ethane	mol %	1,47
Propane	mol %	0,43
i-Butane	mol %	0,129
n-Butane	mol %	0,09
i-Pentane	mol %	0,045
n-Pentane	mol %	0,016
Hexan +	mol %	0,048
Nitrogen	mol %	3,23
Carbon dioxide	mol %	0,213
Heating value	*MJ/Nm^3*	*39,5*
Density	*kg/Nm^3*	*0,76*
Wobbe index	*MJ/Nm^3*	*51,56*

After the test in the DGC GC, tests with the Hobre HIGAS instrument were made. After one-point methane calibration a Wobbe Index of 52,165 MJ/Nm^3 was measured for the gas sample taken in Poland.

Below the HIGAS display readings can be seen.

6 Conclusion

The tests made by DGC showed that the HIGAS unit

- Is easy to use.
- Has short start-up (warm-up) time, approx. 5 minutes.
- Is not pressure sensible within the required sample gas pressure.
- Is easy to calibrate (usually one-point calibration is used).
- Has reasonable operation time in battery operation mode.
- Is relatively heavy

Sample gas can be delivered at low pressure (0 – 100 mbar). This means that tests can be made from supply gas pressure through a reduction valve. As the sample gas flow is relatively low, also samples from e.g. Teflon bags can be analysed.

As it can be seen in both the DGC laboratory measurements and the field tests, the Hobré HIGAS unit received shows a higher Wobbe number than calculated on the basis of certified gas analysis. At the low-Wobbe laboratory test gasses used, the deviation is approx. 0,7 MJ/Nm^3 up to some 1,0 MJ/Nm^3 for the higher-Wobbe gasses. This equals +1,6 to +2 % which is higher than given in the specifications where an accuracy of ±0,5 MJ/Nm^3 and a repeatability of ±0,22 MJ/Nm^3 is stated.

For the field tests the Hobré HIGAS instruments also showed a higher Wobbe index than the GC analysis. The deviation is from approx. +0,65 to 0,78 MJ/Nm^3 equal to 1,2 – 1,5 %.

If this systematic high reading was corrected by – 1 MJ/Nm^3 the HIGAS Wobbe index for the gasses used at the DGC tests would have been within a tolerance of < 0,4 MJ/Nm^3.

In a number of tests, a small but steady drift to higher Wobbe Index read out could be seen if the HIGAS equipment was connected to the sample for hours. A temperature increase in the internal oven is also seen over time (550 ^{o}C to 750 ^{o}C); if this might be a reason for drift DGC cannot tell.

After the test, DGC returned the HIGAS equipment to the manufacturer according to agreement. The manufacturer has also received a copy of the draft report for possible comments. Supplementary tests were performed at manufacturer's site in the Netherlands. The manufacturer's findings are as follows:

- After start-up the instrument does have an initial drift towards higher readings over time (up to 30-45 minutes); the instrument might be turned on (eventually battery supplied during transportation) before metering takes place to minimise this effect.
- If short-time Wobbe Index tests are made, Hobré also finds that a correction of the reading should be made. Hobré's proposal for this is approx. 600 kJ/Nm^3. By doing this, accuracy is within the specified range for the tests performed at Hobré premises.
- The unit supplied to DGC allowed metering before the internal oven temperature reached 750 °C. This is not the case for the commercial units supplied afterwards. Heating to 750 °C takes approx. 10 minutes.

Enclosure 1

Technical specifications for the Hobré Wobbe number meter as presented in the factory brochure

Technical specifications

General

Applications	Natural gas, green gas
Measuring principle	Flameless combustion with residual oxygen measurement
Location	Inside, safe area
Models	Portable, stationary
Calibration	Automatic on 100% methane

Performance

Wobbe index	40 – 60MJ / Nm^3*
Accuracy	± 0,5 MJ / Nm^3
Repeatability	± 0,2 MJ / Nm^3
Response time	T90 < 15 seconds
CARI (Combustion Air Requirement Index)	Max. span 15 in 0 – 25 range
Accuracy	< ±1% of full scale
Total sulfur	< 30 mg / Nm^3*

** Contact factory for other ranges*

Interface

Display	Local color touchscreen, service port TCP/IP
Analog outputs	2x 4–20mA active or passive, maximum load ≤ 600 Ω
Digital outputs	2x relay SPST for "in alarm" and "in calibration"
Digital inputs	for "start calibration" and "start validation"
Communication	Modbus RTU via RS485 and Modbus TCP/IP

Utilities

Power supply	115 / 230VAC, 50 / 60Hz or 24VDC (optional battery pack included – portable version)
Power consumption	50VA max.
Instrument air	Not required (internal air pump included)
Sample flow	< 0,1 Nl/min (filtered)
Sample pressure	0.1 barG standard *

** Pressure reducer available on request*

Installation

Installation	Wall mounting (stationary version)
Dimensions (HxWxD)	500 x 400 x 250mm (depending on configuration)
Weight	≤ 10kg
Enclosure	Epoxy-coated stainless steel
Ambient temperature range	5 – 45°C