

# Assessing the UK’s gas quality measurement infrastructure

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Historically, the UK’s gas quality measurement infrastructure has been designed and installed to measure North Sea natural gas. New gas supplies entering the UK, particularly those from liquefied natural gas (LNG) sources are dramatically changing the dynamics within the national gas network.



*Question: Can our existing measurement infrastructure cope with the new LNG gas compositions found in the network, or are there issues which may cause errors in the calorific value (CV) determination of gas in the UK?*

Natural gas is traded on the basis of its energy content, i.e, its calorific value (CV). Therefore, the accurate determination of gas quality, a generic term used to describe the content (composition) and characteris-

tics (physical properties) of natural gas, is an essential requirement for a public gas transporter.

On the input and output points of a transmission pipeline, the measurement of gas quality is generally performed using online process gas chromatographs (OGCs). These provide a breakdown of the composition of the natural gas in terms of its

individual components (hydrocarbons and inert gases) and the relative amounts of each. From a breakdown of the composition of natural gas, physical properties, such as calorific value, can be calculated.

For over two decades, National Grid Gas (NGG) in the UK has used OGCs as principal devices for the measurement of calorific value. These instruments were installed initially (and have been operated since) with a design specification covering a range of compositions of natural gases which could be expected from indigenous sources in the UK continental shelf (UKCS). This measurement range was specified as the combination of extremes in component amount fractions that could occur from naturally occurring wellhead compositions in the southern, central and northern sectors of the North Sea and those lying off the north-west coast of England. Natural gases flowing through NGG metering points would therefore be expected to lie within this range. However, with the recent importation and introduction of liquefied natural gas (LNG) into the network the situation has changed dramatically.

Due to the liquefaction requirements at LNG production facilities, the source natural

**Table 1. Range comparison of natural gas and LNG expected in the UK national transmission system**

Component	Natural gas (%mol/mol)		LNG (%mol/mol)	
	Minimum	Maximum	Minimum	Maximum
Nitrogen	0.44	7.14	0.08	3.88
Carbon dioxide	0.06	2.18	nil	nil
Methane	83.48	93.31	85.13	92.74
Ethane	2.81	7.33	6.32	8.68
Propane	0.5	2.41	0.02	1.87
Iso-butane	0.09	0.48	<0.001	0.26
N-butane	0.11	0.89	<0.001	0.17
Neo-pentane	0.006	0.011	<0.001	
Iso-pentane	0.023	0.279	<0.001	
N-pentane	0.015	0.230	<0.001	
C <sub>6</sub> +	0.004	0.187	<0.001	



gas is generally processed to remove carbon dioxide and higher hydrocarbons. The processing also tends to remove the majority of the nitrogen. As a result, re-gasified LNG imported into the UK has a profoundly different composition breakdown to unprocessed indigenous UKCS gas.

The introduction of such gas into the network has raised questions from the operators, transporters, shippers and end users of the gas as to whether the existing installed infrastructure is suitable for the measurement of the new composition profiles present in the network.

The composition profile of gas from LNG sources is significantly different in that the amounts of some components may be present in such small quantities that the GC is unable to detect them due to a lack of sensitivity. This is true in particular for carbon dioxide (never present in LNG sources), the butanes, pentanes and hexane components. The consequence of this means the analysis reports from the GCs may contain unmeasured amounts for these heavier components. In fact, the report may contain, in some extreme cases, non-zero values for only four components from Table 1: nitrogen, methane, ethane and propane. Such a significant change in the analysis report may cause concern to many operators, making them question the correct operation of their equipment and the accuracy of the generated data.

EffecTech, as an independent gas quality consultancy, was commissioned by NGG to undertake a study to evaluate the potential

consequence of the situation described above. This in part was to prove or disprove the fitness for purpose of the population of network OGCs for the measurement of both natural gases and re-gasified LNGs with the required accuracy, and to identify any remedial work which may be necessary to be performed by NGG to ensure the required accuracy is maintained.

The study involved:

- Determining the limits of detection of natural gas components on two examples of online GCs used by National Grid Gas on the UK's gas network
- Collecting samples of re-gasified LNG from major importation terminals to the UK and characterising their detailed composition by laboratory analysis.
- Measuring these samples on the same two online GCs and examining any apparent errors in calorific value (CV).

Two instruments routinely used on NGG sites were sourced and evaluated at the EffecTech laboratory. Limits of detection (LOD) were assessed by successive dilutions of a specially prepared reference gas mixture.

Table 2 summarises the limits of detection for the two instruments used in this study named GC #1 and GC #2. Values for methane and ethane are not included, since they are reliably measured at the highest dilution.

**Table 2. Limit of detection – Instrument 1**

Component	LOD (GC #1)/ (ppm mol/mol)	LOD (GC #2)/ (ppm mol/mol)
Nitrogen	<25	<50
Carbon dioxide	30	75
Propane	50	<50
Iso-butane	10	30
N-butane	10	20
Neo-pentane	15	20
Iso-pentane	20	20
N-pentane	25	20
N-hexane	5	25

A set of real LNG samples was collected by EffecTech engineers from a variety of receiving terminals representative of those exporting the majority of LNG-type processed gas into the UK transmission system network. Hence, these real reference samples would be representative of those measured by existing online gas chromatographs.

Table 3 shows the LNG samples collected for this study.

The detailed laboratory analyses of these samples were able to quantify accurately low amounts of C<sub>4</sub>, C<sub>5</sub> and C<sub>6</sub>.

**Table 3. Reference LNG sample collected from UK receiving terminals**

Source	Line pressure/ bar	Actual pressure/bar	Line temperature/°C
<b>Isle of Grain, NTS1</b> sample taken 3rd July 2012 at 10:09am	55	54	20.8
<b>Dragon LNG Stream B</b> sample taken 26th June 2012	15	16	46
<b>Dragon LNG Stream A</b> sample taken 26th June 2012	15	16	48
<b>South Hook LNG</b> sample taken 29th June 2012	6.5	6.5	12.9
<b>Isle of Grain, Jetty 8</b> sample taken 3rd July 2012 at 10:26am	6	5.6	24

## TECHNICAL FEATURE



and above components with a more sensitive detector and with a much lower limit of detection.

One example of these comparisons and the effects on calculated CV is shown in Table 4.

**“The compositions of natural gas and LNG can be profoundly different.”**

**Table 4. Isle of Grain (NTS1) gas**

	Reference analysis	GC #1 measured analysis	GC #1 error		GC #2 measured analysis	GC #2 error	
			Absolute %mol/mol	Relative %		Absolute %mol/mol	Relative %
Nitrogen	3.049	3.072	0.023	0.76%	3.023	-0.026	-0.85%
CO <sub>2</sub>	0	0	0	0.00%	0	0	0.00%
Methane	89.011	88.959	-0.052	-0.06%	89.110	0.099	0.11%
Ethane	7.817	7.852	0.035	0.45%	7.798	-0.019	-0.25%
Propane	0.1211	0.1149	-0.0062	-5.14%	0.0697	-0.0514	-42.42%
Iso-butane	0.00163	0.00124	-0.00039	-23.93%	0.00000	-0.00163	-100.00%
N-butane	0.00131	0.00100	-0.00031	-23.93%	0.00000	-0.00131	-100.00%
Neo-pentane	0.00001	0.00000	-0.00001	-100.00%	0.00000	-0.00001	-100.00%
Iso-pentane	0.00028	0.00000	-0.00028	-100.00%	0.00000	-0.00028	-100.00%
N-pentane	0.00022	0.00000	-0.00022	-100.00%	0.00000	-0.00022	-100.00%
C <sub>6</sub> +	0.00033	0.00000	-0.00033	-100.00%	0.00000	-0.00033	-100.00%
CV / MJ.m <sup>-3</sup>	38.934	38.930	-0.004	<b>-0.01%</b>	38.905	-0.029	<b>-0.07%</b>

### Conclusions

LOD values have been established for both OGCs for carbon dioxide, propane, butanes, pentanes and C<sub>6</sub>+. Carbon dioxide should not be present in LNG and was not found in any of the LNG samples during the reference measurements. Propane is unlikely to be present at amounts as low as the LOD, so the main focus is on butanes, pentanes and C<sub>6</sub>+

LOD values differ between components and, for the same components, between instruments. GC #1 has a lower LOD for butanes and C<sub>6</sub>+ than GC #2, and a comparable LOD for pentanes.

For GC #1, errors in calculated CV are trivial by comparison to an acceptable CV error of 0.1 MJ.m<sup>-3</sup> (0.25% relative). For GC #2, the errors are larger, but still acceptable if considered individually. If, although unlikely, all C<sub>4</sub>, C<sub>5</sub> and C<sub>6</sub>+ components are present just below their respective LODs and their contributions are summed, the total error could be as high as 0.04 MJ.m<sup>-3</sup>.

When results from the OGCs are compared with the reference measurements on real LNG samples, results from GC #1 give CV errors which are negligible. Errors from GC #2 are again larger. It appears that the largest contribution to this error comes from the propane determination, which is very variable in the region of the LOD on GC #2. If the contributions from C<sub>4</sub>, C<sub>5</sub> and C<sub>6</sub>+ only are considered, the error will be acceptably small.

Both analysers gave acceptably small errors in CV on typical LNG samples. In the worst case scenario, where components were assumed to be present at just below their limit of detection, errors were larger but still acceptably small.

*Answer: This study concludes that, although the compositions of natural gas and LNG can be profoundly different, the current gas quality measurement infrastructure in place on the UK gas network is capable of measuring gas from both sources with acceptable accuracy. ■*

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