CERTIFICATE OF ANALYSIS

Approved signatory
Name: **Alisha Patel**
Signature

Issued by **EffecTech**
Date of issue **24 July 2024**
Certificate number **24/0206/11**

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UKAS TESTING 1927

Customer	: Southern Gas Networks plc Fullarton House, 1 Fullarton Drive, Cambuslang, G32 8FD.
Analysis method	: Sample analysed by ISO 6974-1:2012 - *Natural Gas - Determination of composition and associated uncertainty by gas chromatography - Part 1 : General guidelines and calculation of composition*
Sample identification	: Sample point: Beattock Compressor Station, 2024-07-13, 13:30 hrs, line pressure 61.1 bar, line temperature 11.4 ℃, sampled by R. Bell, sample vessel #CB4044.
Date of analysis	: 19 July 2024

This laboratory was not responsible for the sampling stage as the sample and sample identification information was provided by the customer. The results presented in this certificate apply to the sample analysed on an as received basis.

Composition

component	amount fraction (%mol/mol)	component	amount fraction (%mol/mol)
helium	0.00743 ± 0.00029	benzene	0.00039 ± 0.00004
hydrogen	0.00184 ± 0.00009	cyclohexane	0.00036 ± 0.00004
argon	0.00432 ± 0.00019	heptanes†	0.00055 ± 0.00005
oxygen	<0.0015	n-heptane	0.00006 ± 0.00002
nitrogen	0.8153 ± 0.0036	toluene	0.00006 ± 0.00002
carbon dioxide	1.9347 ± 0.0047	methylcyclohexane	0.00011 ± 0.00002
methane	90.268 ± 0.022	octanes†	0.00002 ± 0.00001
ethane	5.533 ± 0.013	n-octane	<0.00001
propane	1.1963 ± 0.0042	nonanes†	‡<0.00001
iso-butane	0.08841 ± 0.00080	n-nonane	<0.00001
n-butane	0.12217 ± 0.00080	decanes†	‡<0.00001
neo-pentane	0.00035 ± 0.00004	n-decane	<0.00001
iso-pentane	0.01301 ± 0.00026	undecanes†⋆	‡<0.00001
n-pentane	0.01072 ± 0.00023	n-undecane⋆	<0.00001
2-methylpentane	0.00096 ± 0.00007	dodecanes†⋆	‡<0.00001
3-methylpentane	0.00052 ± 0.00005	n-dodecane⋆	<0.00001
2,2-dimethylbutane	0.00013 ± 0.00002		
hexanes†	0.00060 ± 0.00005	C_6+ (hexanes+)§	0.00465 ± 0.00015
n-hexane	0.00089 ± 0.00006		

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, which for a normal distribution provides a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with JCGM 100:2008 - *Evaluation of measurement data - Guide to the expression of uncertainty in measurement* (GUM).

⋆ these components/quantities are not UKAS accredited as they lie outside the scope of accreditation for our laboratory

† the amount fraction of a grouped component is the sum of all isomers in that group **except** for those identified separately.

‡ no **individual** isomers could be measured above this limit of detection.

§ the C_6+ (hexanes+) component is the sum of amount fractions of all hydrocarbons containing 6 carbon atoms or greater.

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Physical Properties

Reference conditions	**primary** combustion 15 °C metering 15 °C		**secondary** combustion 0 °C metering 0 °C	
mean molar mass	17.899 ± 0.018	kg·kmol^{-1}	17.899 ± 0.018	kg·kmol^{-1}
compression factor	0.9976 ± 0.0010		0.9971 ± 0.0010	
Real gas properties				
superior calorific value	39.211 ± 0.039	MJ·m^{-3}	41.448 ± 0.041	MJ·m^{-3}
	924.90 ± 0.92	kJ·mol^{-1}	926.34 ± 0.93	kJ·mol^{-1}
	51.674 ± 0.052	MJ·kg^{-1}	51.755 ± 0.052	MJ·kg^{-1}
inferior calorific value	35.384 ± 0.035	MJ·m^{-3}	37.351 ± 0.037	MJ·m^{-3}
	834.63 ± 0.83	kJ·mol^{-1}	834.77 ± 0.83	kJ·mol^{-1}
	46.631 ± 0.047	MJ·kg^{-1}	46.639 ± 0.047	MJ·kg^{-1}
relative density	0.61923 ± 0.00062		0.61942 ± 0.00062	
density	0.75881 ± 0.00076	kg·m^{-3}	0.80086 ± 0.00080	kg·m^{-3}
superior Wobbe index	49.829 ± 0.050	MJ·m^{-3}	52.664 ± 0.053	MJ·m^{-3}
Ideal gas properties				
superior calorific value	39.116 ± 0.039	MJ·m^{-3}	41.329 ± 0.041	MJ·m^{-3}
	924.90 ± 0.92	kJ·mol^{-1}	926.34 ± 0.93	kJ·mol^{-1}
	51.674 ± 0.052	MJ·kg^{-1}	51.755 ± 0.052	MJ·kg^{-1}
inferior calorific value	35.299 ± 0.035	MJ·m^{-3}	37.243 ± 0.037	MJ·m^{-3}
	834.63 ± 0.83	kJ·mol^{-1}	834.77 ± 0.83	kJ·mol^{-1}
	46.631 ± 0.047	MJ·kg^{-1}	46.639 ± 0.047	MJ·kg^{-1}
relative density	0.61800 ± 0.00062		0.61800 ± 0.00062	
density	0.75698 ± 0.00076	kg·m^{-3}	0.79855 ± 0.00080	kg·m^{-3}
superior Wobbe index	49.758 ± 0.050	MJ·m^{-3}	52.572 ± 0.053	MJ·m^{-3}

Auxiliary properties

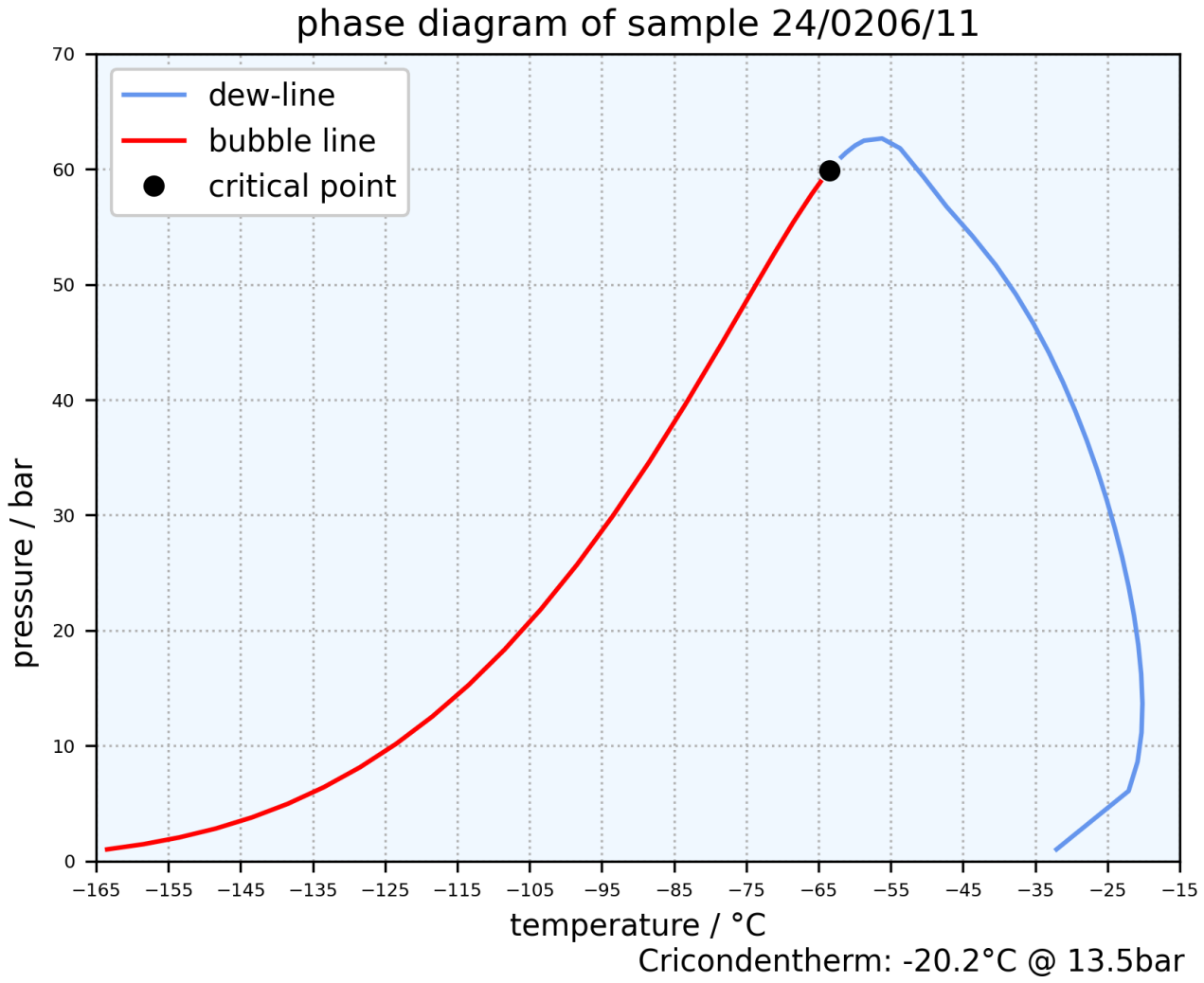
The following additional properties are calculated from equivalent composition in accordance with the UK Statutory Instrument 1996 No.551 *Gas Safety (Management) Regulations 1996 - Regulation 8 (Schedule 3) - Content and other Characteristics of Gas - Part III - Interpretation*

sooting index	0.5153
incomplete combustion factor	-0.4279

The physical properties above are calculated from composition at a reference pressure of 1.01325 bar and at the combustion and metering temperatures stated in accordance with the international standard ISO 6976:1995 - *Natural Gas - Calculation of calorific value, density, relative density and Wobbe index from composition* (including amendment No.1 - May 1998).

Note 1: In accordance with the recommendations of the international standard, the gas mixture is assumed dry (free from moisture).
Note 2: For the purpose of these calculations grouped components are given the property of the corresponding normal alkane.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, which for a normal distribution provides a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with JCGM 100:2008 - *Evaluation of measurement data - Guide to the expression of uncertainty in measurement* (GUM).


phase diagram of sample 24/0206/11
dew-line
bubble line
critical point
pressure / bar
temperature / °C
Cricondentherm: -20.2°C @ 13.5bar
0
10
20
30
40
50
60
70
−165
−155
−145
−135
−125
−115
−105
−95
−85
−75
−65
−55
−45
−35
−25
−15