CERTIFICATE OF ANALYSIS

Approved signatory
Name: **Ryan Richards**
Signature

Issued by **EffecTech**
Date of issue **07 August 2024** Certificate number **24/0055/13**

EffecTech
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Customer	: Gas Networks Ireland Gasworks Road, Cork, County Cork, T12 RX96, Ireland.
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: SC-2002 Bellanaboy, 2024-07-23, 08:30 hrs, line pressure 75.6 bar, line temperature 23.4 ℃, sample vessel TR3037. Other details: Dewpoint: -16.7 ℃.
Date of analysis	: 06 August 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	0.02115 ± 0.00062	benzene	0.00077 ± 0.00006
hydrogen	<0.0005	cyclohexane	0.00006 ± 0.00002
argon	0.01422 ± 0.00025	heptanes†	0.00274 ± 0.00012
oxygen	<0.0015	n-heptane	0.00010 ± 0.00002
nitrogen	2.7173 ± 0.0063	toluene	0.00071 ± 0.00006
carbon dioxide	0.3340 ± 0.0016	methylcyclohexane	0.00047 ± 0.00005
methane	93.746 ± 0.019	octanes†	0.00062 ± 0.00006
ethane	2.9238 ± 0.0085	n-octane	0.00004 ± 0.00001
propane	0.1424 ± 0.0011	nonanes†	0.00074 ± 0.00007
iso-butane	0.04997 ± 0.00057	n-nonane	<0.00001
n-butane	0.01573 ± 0.00034	decanes†	0.00020 ± 0.00003
neo-pentane	0.01129 ± 0.00025	n-decane	<0.00001
iso-pentane	0.00660 ± 0.00019	undecanes†⋆	0.00007 ± 0.00002
n-pentane	0.00147 ± 0.00009	n-undecane⋆	<0.00001
2-methylpentane	0.00147 ± 0.00008	dodecanes†⋆	‡<0.00001
3-methylpentane	0.00061 ± 0.00005	n-dodecane⋆	<0.00001
2,2-dimethylbutane	0.00619 ± 0.00019		
hexanes†	0.00065 ± 0.00005	C_6+ (hexanes+)§	0.01572 ± 0.00029
n-hexane	0.00029 ± 0.00004		

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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UKAS accredited testing laboratory no.1927

Certificate number

24/0055/13

Physical Properties

Reference conditions	**primary** combustion 15°C metering 15°C		**secondary** combustion 0°C metering 0°C	
mean molar mass	16.963 ± 0.017	kg·kmol^{-1}	16.963 ± 0.017	kg·kmol^{-1}
compression factor	0.9979 ± 0.0010		0.9975 ± 0.0010	
Real gas properties				
superior calorific value	37.630 ± 0.038	MJ·m^{-3}	39.776 ± 0.040	MJ·m^{-3}
	887.91 ± 0.89	kJ·mol^{-1}	889.30 ± 0.89	kJ·mol^{-1}
	52.343 ± 0.052	MJ·kg^{-1}	52.426 ± 0.052	MJ·kg^{-1}
inferior calorific value	33.913 ± 0.034	MJ·m^{-3}	35.797 ± 0.036	MJ·m^{-3}
	800.20 ± 0.80	kJ·mol^{-1}	800.33 ± 0.80	kJ·mol^{-1}
	47.173 ± 0.047	MJ·kg^{-1}	47.181 ± 0.047	MJ·kg^{-1}
relative density	0.58667 ± 0.00059		0.58682 ± 0.00059	
density	0.71891 ± 0.00072	kg·m^{-3}	0.75872 ± 0.00076	kg·m^{-3}
superior Wobbe index	49.129 ± 0.049	MJ·m^{-3}	51.924 ± 0.052	MJ·m^{-3}
Ideal gas properties				
superior calorific value	37.552 ± 0.038	MJ·m^{-3}	39.676 ± 0.040	MJ·m^{-3}
	887.91 ± 0.89	kJ·mol^{-1}	889.30 ± 0.89	kJ·mol^{-1}
	52.343 ± 0.052	MJ·kg^{-1}	52.426 ± 0.052	MJ·kg^{-1}
inferior calorific value	33.842 ± 0.034	MJ·m^{-3}	35.706 ± 0.036	MJ·m^{-3}
	800.20 ± 0.80	kJ·mol^{-1}	800.33 ± 0.80	kJ·mol^{-1}
	47.173 ± 0.047	MJ·kg^{-1}	47.181 ± 0.047	MJ·kg^{-1}
relative density	0.58569 ± 0.00059		0.58569 ± 0.00059	
density	0.71741 ± 0.00072	kg·m^{-3}	0.75681 ± 0.00076	kg·m^{-3}
superior Wobbe index	49.068 ± 0.049	MJ·m^{-3}	51.843 ± 0.052	MJ·m^{-3}

Auxiliary properties

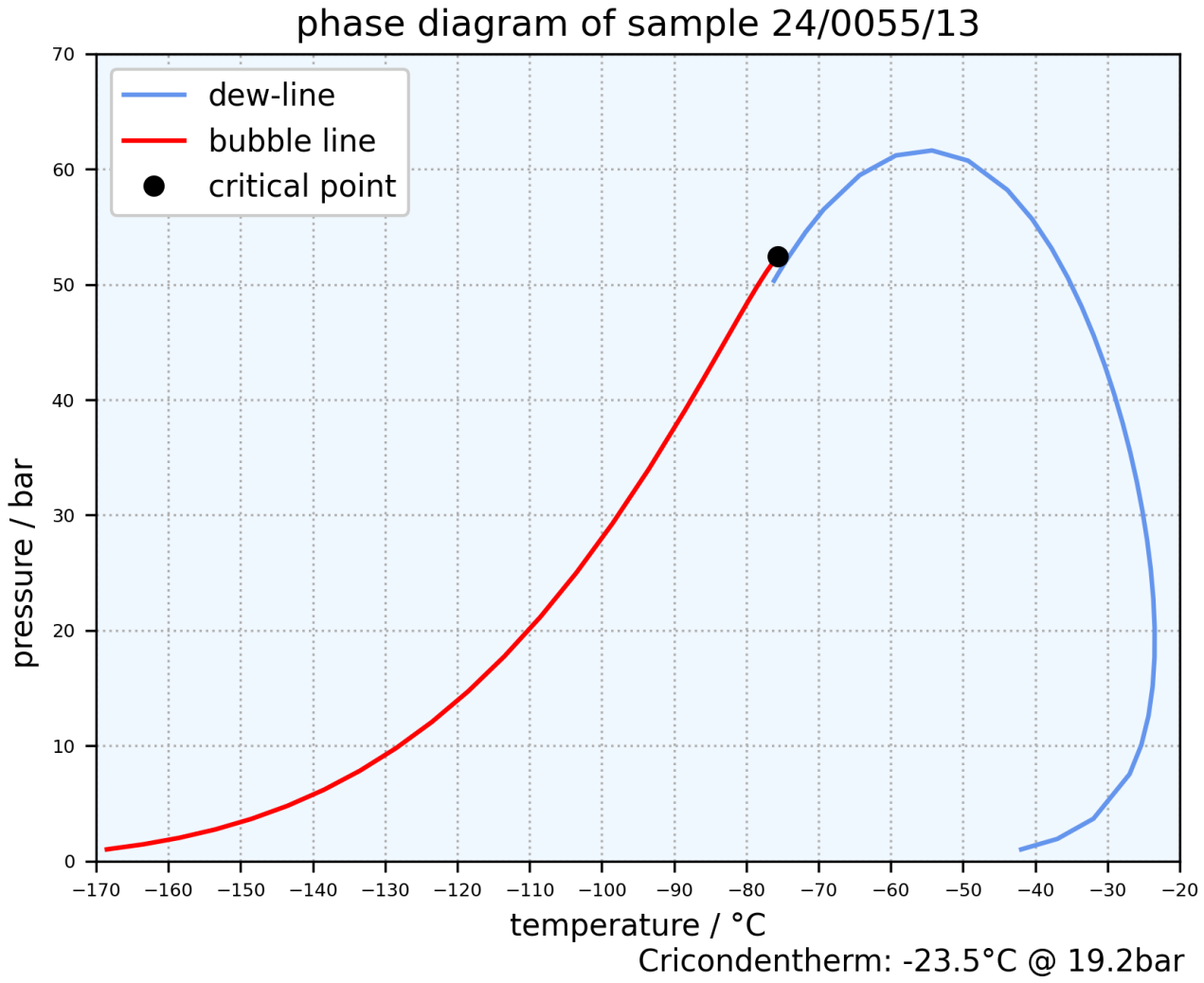
The following additional properties are calculated from equivalent composition in accordance with the UK Statutory Instrument 1996 No.551 *Gas Safety (Management) Regulations 1996 - Regulation 8 (Schedule 3) - Content and other Characteristics of Gas - Part III - Interpretation*

sooting index	0.4767
incomplete combustion factor	-0.9261

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 24/0055/13
dew-line
bubble line
critical point
pressure / bar
temperature / °C
Cricondentherm: -23.5°C @ 19.2bar
0
10
20
30
40
50
60
70
−170
−160
−150
−140
−130
−120
−110
−100
−90
−80
−70
−60
−50
−40
−30
−20