National situations regarding gas quality
Report prepared[1] by MARCOGAZ working group "GAZ QUALITY"

CONTEXT

During its Geneva meeting in November 2001, the Standing Committee "Gas Utilisation" of Marcogaz decided to set forth a working group to address the question of the impact of gas variation on appliances technology. This working group held its first meetings on May 17, June 28 and September 3, 2002. During those meetings the scope of work and subsequent actions were decided as follows:

- The work shall be split between generic applications. For each one an investigation of the effect of the variation of the different specifications of natural gas shall be studied,
- In parallel, the actual variations of these parameters and the different methods to cope with as existing in each country shall be established.

This second aspect has two objectives. First to give a picture of the current situation but also to give an indication of the differences between countries as the result of harmonisation will probably fall within the current variations when observed on a European scale.

This document makes a review of the parameters used in gas specification around Europe. Then it gives the range of variations for these specifications.

NATURAL GASES AVAILABLE IN EUROPE

The observed variations of natural gas composition in the different countries are obviously related to different origins. Natural gases are separated between the L and H quality as defined in EN 437. Theses gases being non interchangeable, they are supplied in separated networks. The only source of L Gas is Netherlands, whereas H gases as numerous origins (North Sea, Russia, Algeria, Nigeria, …). Transportation of natural gas to Europe is another cause for variations in the composition of H gases as some are liquefied thus stripping the gas of a number of higher hydrocarbons.

PARAMETERS SPECIFIED

Gas specifications don't cover the same parameters in all European countries. The table below shows, for those countries represented in Marcogaz working group, the parameters specified and whether the specifications come from regulation or is contractual. Blue cell indicates legal requirement or a requirement coming from a national standard (as for instance G 260). Yellow cell indicates other origins. The last column summarises the number of country where the parameter is specified out of the 8 countries represented.

[1] This report has been prepared by F. Cagnon (GDF), convenor of the ad hoc group and reviewed and edited by the members of the group, MM. Hec (Marcogaz), De Wit (Technigas), Soerig (DGP),Wackertapp (RG), Viglietti (SNAM), Levinsky (Gasunie), Sahun (Gas Natural) and Lander (Advantica).

Table 1: References conditions and parameters specified in European countries.

		Be	Dk	De	F	It	Nl	Sp	UK	Total
Reference Temp. (°C):	Volume	0	0	0	0	15	0	0	15	
	Energy	25/0	25/0	25/0	0/0	15/15	25/0	0/0	15/15	
Coefficient for energy conversion		0.949	0.949	0.949	0.946	1	0.949	0.946	1	
GCV		L		L	L	L	O	L		6/8
Wobbe index		L	L	L	O	L	O	O	L	8/8
Density			L	L		L				3/8
Methane number										0/8
Hydrocarbon dew point		O	L	L	O	L	O		L	7/8
Water dew point		O	L	L	L	L	O	O	L	8/8
Sulphur	Total	L	L	L	L	L	O	O	L	8/8
	H_2S	L	L	L	L	L	O	L	L	8/8
	Odorant	L	L		O	L	O			5/8
	Mercaptan			L		L	O			3/8
Other indices	Comb. Potential	O								1/8
	Ij	O								1/8
	ICF								L	1/8
	Soot index								L	1/8
CO		O						L		2/8
Carbonyl metals		O								1/8
Impurities (liquids, solids)			L	L	O	L	O		L	6/8
CO_2					O	L	O	O		4/8
N_2								O		1/8
O_2				L	O	L	O		L	5/8
H_2					O				L	2/8
Aromatic							O			1/8
NH_3								L		1/8

Note 1: Other indexes relates to indexes use for interchangeability.

Note 2: In every country there is a legal requirement that gas shall be odorised. Thus if the table shows an indication for odorant specification it means that an actual concentration of odorant is specified to fulfil this obligation. This specification may be written in a standard. In some countries a specification on mercaptan concentration is made apart from odorisation requirement.

Note 3: Energy parameters have been given using national references. The conversion toward table 1 of EN 437 reference conditions (15°C/15°C) has been made using the method of annex B of ISO 13443. This method is not composition dependant. The average conversion coefficients deduced from the results are given here. Volume conversion is made following perfect gas law.

Wobbe index and sulphur content for H_2S and total sulphur are specified in every country whether by legal requirement or by contractual means. As for the other parameters the situation is very contrasted.

- Denmark, Germany, Italy and Great Britain have their specifications legally driven,
- France, Belgium and Spain specifications are coming from law, contract, agreements or recommendations.
- Netherlands specifications are solely contractual.

The most frequently specified parameters, apart from Wobbe and sulphur, are those related to condensation and odorisation. Oxygen, inert gases and impurities are also specified. Other components as CO, hydrogen are cited once or twice. Only two countries have a specification on additional interchangeability indexes, Belgium which specifies the secondary indexes of the DELBOURG method and UK using specific British indexes.

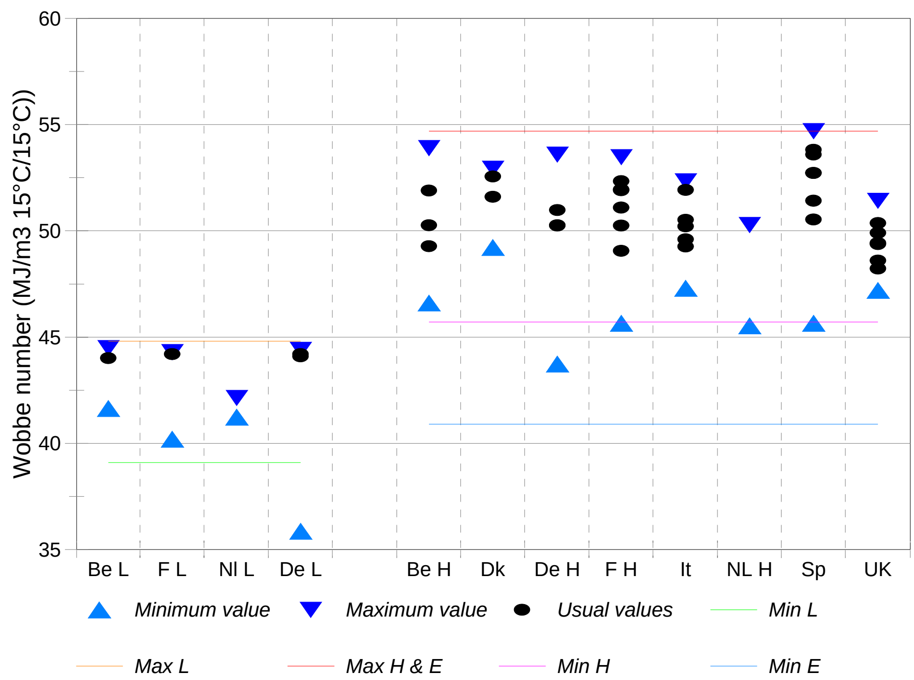
RANGES OF VARIATIONS

Wobbe number

The figure below summarises the variations observed in different countries with the reference conditions for volume and energy being those retained in Table 1 of EN 437:2001 i.e. 15°C and 1013.25 Pa for energy and volume. To convert the data given for each country the method presented in annex B of ISO 13443 has been used. This method is not composition dependant and gives, in the range –3°C +27°C and 95 – 105 kPa a result with a ±0.05% uncertainty.

H gas, as defined in EN 437, is present all around Europe. L gas is distributed only in four countries, the Netherlands, France, Belgium and a very small area in Germany. In these countries L gas and H gas are distributed in separate networks. In France, Belgium and Germany the L network is a regional network, thus L gas concerns a given area within the country. In the Netherlands the L network is distributing gas to domestic, commercial and small industrial customers, whereas the larger industrial customers are connected to a different network supplied with H gas. Gases with widely varying composition are blended to a narrow band of Wobbe numbers.

Figure 1: Wobbe variations and groups of the 2nd gas family (EN 437)



For H gases the potential variations due to different origins are much wider. Belgium, France, Italy, Spain and Great Britain are distributing gases without any restriction within the country as far as its specification falls within those acceptable. In Germany and the Netherlands however gases with different Wobbe index are circulated within confined area, blending being made in a number of stations to compensate for extra variations and to balance regional consumption and supply. In Denmark the usual variations are rather small, as there exist a limited number of supply.

Gross calorific value

GCV is specified in all countries except in UK. However this parameter is never used for technical purposes. Its specification comes often from legal origins and it may simply related to billing as for domestic customers billing is made using a volume measurement converted in energy using an period-typical value of the GCV. This typical value may take different form as:

- Lowest value during the period,
- Average value during the period,

Limitation on the possible variations of the GCV may be used to limit the uncertainty of the methods as a real energy measurement is not yet possible for each customer.

Sulphur

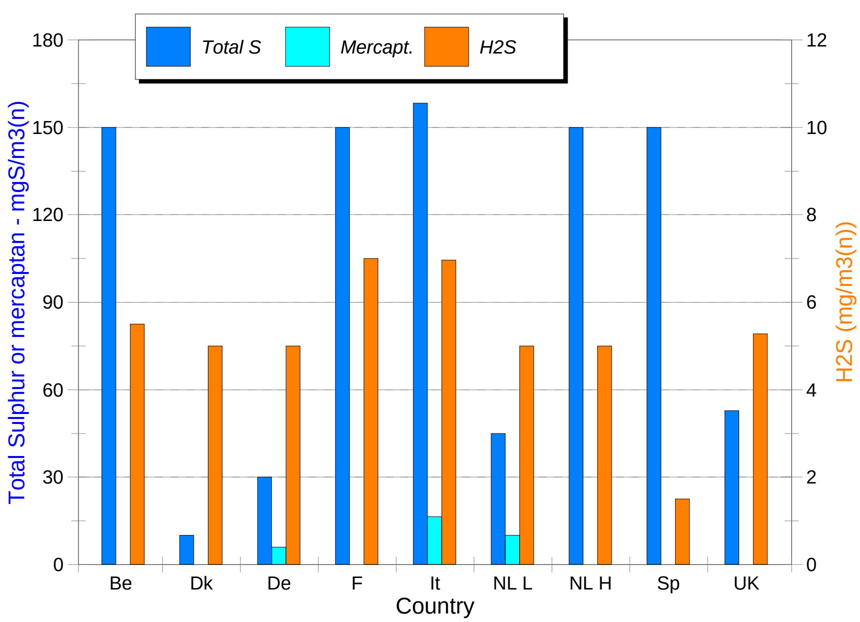
The figure below shows the upper limit values for sulphur compounds. In some cases two different values are specified one being long-term, the other a peak values. It is the case in France for H_2S and Germany for all compounds. For those countries only the average limit value is presented. The following units are used:

- For total sulphur and mercaptans (RSH): mgS/m^3(n), reference condition 0°C, 1013 Pa (left Yaxis).
- For H_2S: mgH_2S/m^3(n), reference condition 0°C, 1013 Pa (right Y axis).

Specification on H_2S are very consistent all around Europe, between 4 and 7 mg/m^3(n). The usual values for H_2S are generally below 4 in every country.

For total sulphur specifications are clearly separated between two groups, Belgium, France, Italy, the Netherlands for H gas and Spain where the limit value is about 150 mg/m^3(n), Denmark, Germany, the Netherlands for L gas and UK accepting much less, from 10 to 50 mg/m^3(n). The origin of these differences is not clear. In the Netherlands some contracts on H gas are specifying lower peak and average values (30 and 20 mg/m^3(n)) respectively.

Figure 2: Sulphur specifications



As for mercaptans, only three countries have a specification with maximum concentrations varying from 6 to 15 mgS/m^3(n). The reason for this specification is unclear. Mercaptans have a strong smell and are used as gas odorant. Such concentration of mercaptans sulphur should give the gas a strong odour, at least equivalent to the one needed for odorisation.

Nowhere distinction in gas transit seems to be made in respect to the H_2S or total sulphur content of the gases. It was only in France that Lacq gas, which used to contain high concentrations of mercaptans, was circulated in order to avoid switches from this gas to other gases odorised with THT in densely populated areas. These switches are known to induce temporarily high levels of odour complains.

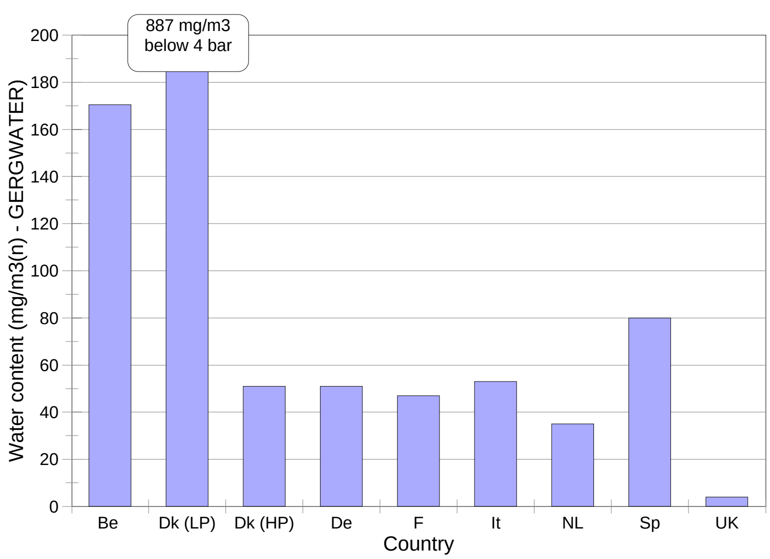
Water and hydrocarbon dew point

A specification exists in every country about water dew point, and also for hydrocarbon dew point except in Spain. These specifications can take three different forms:

- Specified maximum dew temperature for a range of pressure, (ex: -5°C below 60 bar)
- Qualitative statement that can be interpreted as above (ex: below ground temperature for all pressure). Such statement is generally understood at temperature below –4°C or –8°C.
- Qualitative statement as in UK (*"…technically free of…"*). For UK this leads to water due point of about –30°C.

The figure below shows the water content in mg/m^3(n) that can be calculated, using the GERGWATER correlation, following the different specifications. When ground temperature is mentioned, it has been taken at –4°C. When no pressure is stated the calculation is made for a maximum pressure of 80 bar absolute.

Figure 3: Water content as coming from the expression of dew point (using GERGWATER correlation with typical Russian gas composition)

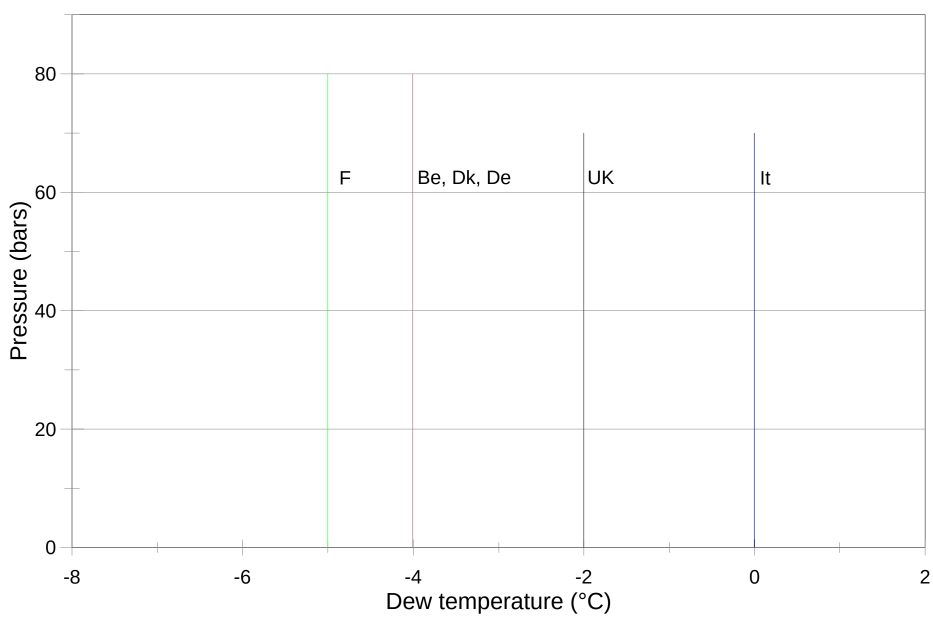


The specification for low-pressure network in Denmark leads to a high water content, probably allowing for manufactured gas and ingress of water in case of work in the distribution network. When the specification covers high-pressure network, the expressions of the water dew point lead to water consistent water concentration, between 40 to 80 mg/m^3(n). Only in Belgium the specification allows for high water content. However this may be related to a regulation applying to distributed gas only, consistent with a maximum pressure of 15 bar, whereas usual values are much smaller. The value for UK represents a typical value for water due point of –30°C and leads to very dry gas.

The specification of hydrocarbon dew point are much more difficult to compare as the dew curve in a graph (Pressure vs. temperature) is not monotonous. Thus the graph below shows the upper limit for the retrograde condensation curve express as a function of temperature and pressure. As for the water dew point, when no figure was given for temperature, ground temperature was taken equalled to -4°C. Maximum pressure was taken at 80 bars if not specified. Except Belgium, no country gives a figure on pressure, the statement implying that the whole pipeline operating range is covered. In Belgium the pressure range given (49 to 66 bar) is roughly where the condensate curves is at its maximum on a (P, T) graph. Thus it should not lead to very different results as if the whole operating pressure range is specified.

The specifications in Belgium, Denmark and Germany are identical, with a temperature at -4°C. UK and France, even if the specified temperature is slightly different can be said to have a similar specification as the current technologies for the determination of HC dew point has an uncertainty of about ±2°C. For the same reason the specification in Italy is not so different from those specifications.

Figure 4: Hydrocarbon dew point



As for Netherlands the specification is not upon a dew point but about a maximum liquid content (5 mg/m^3(n)) below –3°C. This specification is not easily controlled, however it might be lead to a better understanding of the operational trouble coming from hydrocarbon condensates as it will put a limitation on the volume of liquid that can be observed in given condition.

Oxygen

The last specification found in a majority of countries is upon oxygen. In Germany, France, Italy and the Netherlands the oxygen content shall be below 0.5 to 0.6 % (Germany asks this only for wet gases, dry gas can contain up to 3 % O_2). In UK the specification is lower (less than 0.2% O_2).

Other specifications

Dust, liquids and impurities are mentioned in six countries (Dk, De, F, It, NL and UK) out of eight. However the lack of measuring technology or correct definition for these products leads to general formulation such as *"... gas shall be technically free of ..."*.

Other indices for interchangeability than the Wobbe number are mentioned in Belgium and UK. Belgium recognises the need to specify a second parameter to define correctly interchangeability and uses the combustion potential described by Delbourg. This parameter seems to be correlated to the speed of combustion of the gas and is notably changed by inert gases, hydrogen or heavy hydrocarbon. This parameter does not change dramatically as far as one considers *"usual"* natural gases. This may explain why other continental countries, which are using the same interchangeability method, don't specify this parameter.

Two indices for interchangeability are specified in UK according to a work conducted by DUTTON in 1970-1980. The first step of the method is to transform the actual gas composition in an equivalent reference gas composition described as a mixture of methane, propane and nitrogen. Then a diagram is drawn in a 2-axis system, X-axis being the PN number qualifying the propane nitrogen content and the Y-axis being the Wobbe number. A number of curves are defining the interchangeability domain:

- The lift curve, related to the observation of flame lift on cookers,
- The incomplete combustion factor related to the observation of incomplete combustion on water heater,
- The soot index related to the observation of soot on heating appliances.

The current regulation adopted the method of Dutton with some simplifications:

The **ICF** and **SI** are calculated according to the gas composition and their values are limited by the regulation.

Hydrogen is specified in UK (below 0.1%) and there is a recommendation in France (<6%). The specification in UK is related to interchangeability. In France however it seems to be a legacy of the town gas era.

CO_2 has the same specification in France, Italy and Spain: 3% maximum

Carbon monoxide is specified in Spain and Belgium, carbonyl metals in Belgium, aromatic hydrocarbons in the Netherlands. These are probably legacies of the coexistence between town gas and natural gas.

CONCLUSION

This review of gas quality within Europe gives the following convergence:

- The main specifications concern Wobbe index, GCV, sulphur compounds and dew points (water and hydrocarbon).
- The specifications on dew points are quite similar in all the countries represented.
- H_2S specifications are homogenous, whereas sulphur specifications converge toward two values, about 30-50 mgS/m^3(n) and 100-150 mg/m^3(n).
- When specified, oxygen limits are in the same order of magnitude,
- Liquid and impurities clauses are general but with a loose formulation.

A number of varied specifications are formulated by one or two countries, some of those being legacies of town gas distribution.

Except for the Wobbe number, gas is generally not circulated within a country according to the variations of the above specifications. Thus in a given point of the country variations on one of these parameters can theoretically encompass all the specified range.

The main divergences are related to the Wobbe specifications and interchangeability understanding. Wobbe specifications can differ in two ways:

- Different ranges from country to country,
- Different method to cope with Wobbe variations.

The differences in Wobbe ranges that can be observed for gases entering in the same group (H, L or E) may be related to the safety margins that each country have deemed necessary to ensure that apparatus tested according to the EN 437 are working safely. As for Wobbe variations, in Netherlands and Germany gases are blended to insure small Wobbe variations. This allows the customers to adjust, when possible, their appliances and optimise their use of gas. In the other countries gas is circulated on a strict consumption – supply balance. Thus the users shall expect variations of the Wobbe number.

An important issue coming out of this work is the use of secondary interchangeability indices by some countries. Harmonisation of the gas specifications will need to address the usefulness of these indices and define a common indicator that will reflect the interchangeability tests made using EN 437 test gases if needed.