The composition of low calorific gas in the more distant future and the requirements for gas appliances covered by the Gas Appliances Directive.

1. Introduction

This appendix sets out the composition of low calorific gas as network operators can distribute it via the public gas grid from 2021 (or from a later date). This relates to the changes in the 'exit specification' of the gas. No significant changes with respect to the current practice are anticipated for the aspects which are not mentioned. Exit specification means that it is the responsibility of the network operators to deliver gas which complies with this specification. The consumers are thereby responsible for their own gas use if they receive gas which complies with this specification.

A large proportion of gas consumers use gas appliances which are covered by the Gas Appliances Directive (2009/142/EC). In order to ensure that they can cope with the future gas, the proposal for the future gas composition goes hand in hand with the requirements for new appliances in terms of the gas that these appliances can handle. For the sake of clarity, the gas specification for these appliances is also included. In addition, with an eye to the more distant future they must also be suitable for using high calorific gas.

The presented gas composition is the product of contributions from many interested parties. These include the recommendations in chapter 3 of part 2 of the report "Gaskwaliteit voor de toekomst" ["Gas quality for the future"] from KEMA, Kiwa and Arcadis (House document 29023 83 of 28 March 2011). This states that the specification of the gas must be such that:

1. New appliances can cope with the future gas soon with limited additional cost and proven technology.
2. The specification selected for the new appliances is compatible with what is customary in Europe.
3. The gases expected in the future can be brought up to the future specification with limited processing costs.
4. The specification of the future high calorific gasses must be compatible with the distribution specifications which are customary in Europe.

Because of point 3, provision must be made for:

A. More higher hydrocarbons (a higher propane equivalent, PE).
B. Converting high calorific gas too low calorific gas (pseudo-G gas). This is expensive. It is desirable to limit the cost of this conversion.
C. Sustainable gas which can contain different components from natural gas such as CO_2 in green gas and H_2 in gas from the gasification of materials such as biomass.

KEMA and Kiwa also recommend that specifications should be explicit with regard to:

D. The maximum relative density of the gas, so that in the unfortunate event of gases escaping, they are lighter than air and will rise.
E. The speed of the change in the Wobbe index.
F. The speed of the change in the methane number.
G. The bandwidth for the methane number.

2. Future composition of low calorific gas

Table 1. Changes in the composition of low calorific gas as it can be delivered by network operators to users of gas in the distant future (from 2021 or from a later date).

It may be found in due course that the full range is not actually utilised.

		Future composition (2021 or later)	Current composition
1	Wobbe index Gross at 0 °C	43.46 - 45.3 MJ/m^3 The current upper limit on the regional networks of 44.41 MJ/m^3 will be maintained for safety reasons until the practical state of the consumers' installed base is suitable for the higher limit.	43.46 - 44.41 MJ/m^3
2	Higher hydrocarbons content	0-8.1 % propane equivalent	<5% propane equivalent
3	Methane number (according to AVL List 3.2)	> 70 MN and >71 MN if there is hydrogen in the gas.	[not specified]
4	Sulphur content	Peak value: < 30 mg/m^3 (before odorisation). Annual average: < 12 mg/m^3 (after odorisation)	< 45 mg/m^3 (before odorisation). [Annual average not specified]
5	Delivery pressure on 25 mbar connections.	23.7-30 mbar	23.7-32 mbar
6	H_2 content	< 0.5 % (molar)	[not specified]
7	O_2 content	< 0.5 % (molar) RTL < 5ppm (molar) HTL	< 0.5 % (molar)
8	CO_2 content	< 10.5 % (molar)	[not specified]
9	Relative density compared to air	< 0.8	[not specified]
10	Speed of change of the methane number and Wobbe index.	Instantaneous.	[not specified]

Table 1 does not cover all the parameters of the gas composition exhaustively. After all, the aim of this table is to identify the *changes* in the composition compared to now. According to KEMA and Kiwa the table contains all the parameters about which clarity is urgently needed. For components or aspects of the gas which are not listed - such as carbon monoxide or temperature - their absence does not mean that the value is 0 or that the value is unlimited.

In the internet consultation a few parties proposed a number of further parameters in order to give a complete description of the gas composition. KEMA and Kiwa believe that these are not necessary for the clarity to be provided at this point. They recommend that these aspects of the composition such as the water dew point, the hydrocarbon dew point, the calorific value and trace elements be included in the regulations, so that the gas user has clarity about what he can expect. This specification can generally be based on current practice.

Explanation by parameter.

1 Wobbe index

The Wobbe index is the most important parameter for the gas composition. In the Netherlands the Wobbe index is expressed on gross calorific value at 0 °C. The current bandwidth for the Wobbe index will continue to apply for as long as is necessary for consumer safety. This extends from

43.46 to 44.41 MJ/m^3 and is specified by means of a Ministerial Decree. GTS has indicated that it can maintain the Wobbe bandwidth. GTS will incur costs for this which are incorporated in the transportation charges. The costs particularly relate to the addition of nitrogen, which converts high calorific gas into low calorific (G) gas. As soon as the consumers' appliance population can cope with it, the upper limit of the Wobbe index can be raised to 45.3 MJ/m^3. Such a higher Wobbe index will mean that GTS will charge reduced processing costs to the network users[1].

It may be that the conclusion will be reached in due course on the basis of research that it is desirable for the safety of the appliances which have not yet been replaced to reduce the maximum Wobbe slightly where there are high higher hydrocarbons contents, as is done in the United Kingdom.
Another aspect is that it can be desirable, as the Wobbe index's bandwidth widens, for the installer of a gas appliance to be able to obtain the current Wobbe index in order to be able to tune the appliance.
The GTS grid has a number of gas pipelines with different values for the Wobbe index, such as export pipelines which transport low calorific gas with a Wobbe index up to 47 MJ/m^3. It seems obvious that when creating a new direct connection to such a pipe GTS and the customer deal with the possibilities pragmatically.

2 Content Higher hydrocarbons

Groningen gas has a low content of higher hydrocarbons (including ethane and propane). The pseudo-G gas which has been made from the high calorific gas from the small fields for decades also has a generally low content of higher hydrocarbons. The direct cause of the discussion about the change in the gas composition is the decline in production from small fields; foreign gas will have to be used for the production of pseudo-G gas. This foreign gas may contain such a high level of higher hydrocarbons that it is unsure whether the resulting pseudo-G gas can be used safely by appliances. GTS has indicated that the gases which have reached North-West Europe so far have a maximum higher hydrocarbons content after conversion to pseudo-G gas of 8.1% propane equivalent. Gases with even higher levels of higher hydrocarbons are known. However, it is not desirable that all Dutch gas users should also prepare themselves for these rare, extreme gases whilst the current market conditions do not yet suggest that these gases will actually ever reach the Netherlands, let alone will need to be converted to pseudo-G gas.

In discussions which included the internet consultation, various parties have pointed out that it is cost-effective to extract the higher hydrocarbons before distribution in the Netherlands, a process called 'stripping'. My position on this remains unchanged: a network operator like GTS cannot deliver the gas presented for transportation in two separate fractions on its own. However private parties can investigate the business case for stripping the foreign gas at the feed-in points for the Dutch network. To do this they need to extract the gas which has been fed in from the public network, and feed the stripped gas back into the network after separation of the higher hydrocarbons. The higher hydrocarbons are sold separately and may be worth more as a raw material in the chemical industry than they were as a fuel in the gas network.

3 Methane number

The methane number is important when gas is used in gas engines. The gas from the Groningen field has a high methane number, which is beneficial for the knock resistance and also the efficiency of a gas engine. It is not possible to guarantee a high methane number if pseudo-G gas is produced by mixing gases from other sources. Higher hydrocarbons lower the methane number. The operators of gas engines (Combined Heat & Power Plants) will have to prepare for a lower methane number over the coming decade. The cited report entitled 'Gaskwaliteit voor de toekomst' ['Gas quality for the future'] from KEMA, Kiwa and Arcadis sets out what this means. This will bring the gas engines on the Dutch gas grid into line with the gas engines in our neighbouring countries;

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[1] The limits exclude the measuring accuracy of GTS's mixing stations, as also already specified in article 5.2 of the current LNB gas measurement terms. The control inaccuracy of the mixing stations means that gas may be delivered slightly above the limit of 44.41 MJ/m3(n) or below the limit of 43.46 MJ/m3(n) for the Wobbe index part of the time.

the beneficial situation resulting from Groningen gas will gradually come to an end. A higher hydrocarbons content of 8.1% PE (the maximum) would reduce the methane number to 71. Appliances for the supply of emergency power, e.g. the emergency electricity supply in hospitals, must also be adjusted to lower methane numbers. This will prevent a breakdown. If a private party sees commercial opportunities and takes on the 'stripping' described in the previous paragraph, the average and possibly the lowest methane number will be higher.

There are various ways of calculating the methane number. The research institutes KEMA and Kiwa have used the AVL list method (version 3.2). Another calculation method - used by gas engine suppliers - was put forward during the consultation as an even more suitable measure for the performance of gas engines. Broadly speaking, the methane numbers according to this method are some 5 points below those calculated using the AVL list method. If another method is used, the limiting value would naturally have to be modified.

The effects of hydrogen on the knocking behaviour are more negative at low levels than the AVL list method (version 3.2) suggests. The choice has been made that if there is hydrogen in the gas, for which a maximum content of 0.5% applies, the methane number of the gas, calculated for the same composition without hydrogen, cannot be less than 71 (using AVL list method, version 3.2). This comfortably offsets the impact of this limited hydrogen content on the knock resistance.

4 Sulphur content

The current maximum sulphur content is 45 mg/m^3 before odorisation. The network operators have submitted a proposal to the Netherlands Competition Authority to reduce this to 30 mg/m^3. This peak value determines the maximum capacity of any desulphurisation facilities at end-users and parties that feed in.

Manufacturers and users of gas appliances are concerned about a permanent exposure to the maximum content, and not about short-term peaks. Based on the historic practice and GTS's expectations of the feed-in the average annual level for the maximum total sulphur content before odorisation is 5 mg/m^3, and after odorisation this maximum is around 11.5 mg/m^3.

As a result the limit of 30 mg/m^3 before odorisation is adopted as the maximum peak value for an appliance and the annual average for the total sulphur content may not exceed 12 mg/m^3 (after odorisation).

It is possible that parties which currently feed in green gas will have to modify their desulphurisation plants in the future in order to comply with this additional requirement. However, stipulating more stringent desulphurisation requirements results in lower social costs than making all appliances suitable for high sulphur levels.

5 Delivery pressure on 25 mbar connections

The customary delivery pressure for the distribution of G gas will not change, and will remain at 25 mbar, but the limits are changing and will be 23.7 to 30 mbar instead of the current 23.7 to 32 mbar. Under the European requirements appliances are suitable for 20 mbar as the lowest pressure and 30 mbar as the highest pressure. Because the pipes between the Network operator's delivery point and the location where the appliance is installed suffers some loss of pressure, the minimum delivery pressure has been kept at 23.7 mbar.

6 Hydrogen (H_2) content

Hydrogen may play an important role in future energy supply, including as a component of gasification gas, a form of renewable energy. Whether this will materialise depends on all sorts of technical developments and financial aspects. As a result it is not currently certain whether, and if so when and to what extent, there will be a need to feed hydrogen into the gas network in higher percentages. It could be a heavy burden for a number of parties in the chain to have to prepare to cope with significantly higher proportions. This burden applies both to parts of the transportation system (metal pipes) and to consumers (e.g. gas turbines). This burden is so severe that it will not be imposed, despite the possibilities which the potential feed-in of hydrogen into the public networks could offer. The future composition of low calorific gas therefore includes a maximum of 0.5%. If there are reasons for considering the distribution of higher percentages of hydrogen in the more distant future, which will probably only be in the regional networks, there will have to be consultation with the various sectors about the possibilities and consequences.

The gasification of biomass and waste streams is an option for producing renewable gas in the future. Unprocessed gasification gases contain a great deal of hydrogen and highly toxic carbon monoxide. The resistance to the distribution of carbon monoxide via the public gas supply is strong. The limits for carbon monoxide will therefore remain at the current level. Industrial applications and electricity-generating plants can suffer light-back and/or ignite prematurely at high hydrogen percentages. The effect on the integrity of the networks also needs to be investigated. It is very possible, incidentally, to convert gasification gas into synthetic natural gas (SNG) with an extra processing step. Following this methanisation step it requires a lot of energy to remove the remaining hydrogen from the gas. This is a concrete situation for which the limit of 0.5% H_2 could be applied.
GTS will have to incur additional costs in order to include hydrogen in the official quality measurement.
For the relationship between hydrogen and the methane number please see the explanation at point 3 concerning the methane number.

7 Oxygen (O_2) content

The oxygen content has been included because a substantial increase from the current 0.5% to 4% for example would offer the possibility of converting high calorific gas into pseudo-G gas by adding air instead of nitrogen. (Air consists of around 80% nitrogen and 20% oxygen). This possibility met with little enthusiasm amongst the stakeholders. The current maximum oxygen proportion is therefore being maintained as applies for GTS's medium pressure network (RTL).
For the higher pressure transportation system (HTL) GTS is striving for an increase in the limit from 5 ppm to 10 ppm, so that the Netherlands fits in with the rest of Europe. A maximum of 5000 ppm (=0.5 %) applies for the medium pressure system (RTL). This higher value is important for the feed-in of green gas in this grid.

8 Carbon dioxide (CO_2) content

The policy is aimed at incorporating as much green gas as possible into the future gas supply. Green gas derived from the fermentation of biomass contains a great deal of CO_2. As a result, gas in the future will be allowed to contain relatively high CO_2 content of 10.5%.
CO_2-containing gases are (generally speaking) more prone to 'blow off' than N_2-containing gases at the same Wobbe index.

A high CO_2 content can, incidentally, only be permitted for relatively dry gas because of the risk of corrosion of both the networks and the gas-carrying parts of gas appliances.

During the internet consultation various parties noted that there is a European upper limit. However, this relates to a proposal for cross-border transport streams.

9 Relative density compared to air

In the unfortunate event of gas leaks, it is necessary for safety reasons that gas be lighter than air and rises. For this reason KEMA and Kiwa have recommended that a maximum be stipulated for the relative density of gas compared to air.

10 Speed of change in the methane number and Wobbe index

The network operators have no way of preventing instantaneous changes in the gas composition for users. The network operators have no control over the amount and location of feed-in and extraction from the complex branched network. Those parties that feed in and extract have transportation capacity which they can utilise - or not - without notification. Gas mixes to a very limited extent in the gas network; only at a few locations where gas is intentionally mixed can the gas composition be managed. Network operators cannot control the speed of change in the Wobbe index and the methane number; instantaneous changes remain possible.
For example: if gas is fed in from two sides, a consumer located on the boundary between the two streams can experience an instantaneous change in gas composition, depending on the consumption by their neighbours to the left and right or a change in the supply from the left or the right.

This is also described in detail in the document ‘Kwaliteitsvariaties op transport’ [‘Quality variation during transportation’ from Projectbureau Nieuw Aardgas [Project Office New Natural Gas] (see www.projectbureaunieuwaardgas.nl).
Many parties have indicated that they anticipate problems with the instantaneous fluctuations. In view of the bandwidth of the Wobbe index of up to +/- 2% for G gas, it can be expected that domestic appliances which are designed for this will not have any problem with an instantaneous change in the Wobbe index within this bandwidth. The changes in the methane number and the Wobbe index will pose a considerably greater challenge for designing power stations and gas engines which are both energy-efficient and can cope with changes in the Wobbe index.

3. Requirements for gas appliances sold new in the market under the Gas Appliances Directive

For the requirements for new gas appliances it is assumed that the appliances can be set for a low calorific Wobbe index ('G gas setting') and a high calorific Wobbe index ('H gas setting'). An installer can switch the appliance from one setting to the other. This is a one-off switch-over.

The appliance category I_{2E} is required for the high calorific setting. This fits with the German specification. This also means that the appliance pre-pressure is lower than with current and anticipated G gasses: 17 to 25 mbar.

On the low calorific setting the appliances must be able to handle the anticipated low calorific gases. This has been set out in the table below.

		G gas setting
1	Wobbe index	
	Standard [Gross CV at 0 °C] ([Gross CV at 15 °C])	44.41 MJ/m^3 (42.02 MJ/m^3)
	Maximum Gross CV at 0 °C] ([Gross CV at 15 °C])	45.3 MJ/m^3 (42.86 MJ/m^3)
	Minimum Gross CV at 0 °C] ([Gross CV at 15 °C])	43.46 MJ/m^3 (41.12 MJ/m^3)
2	Higher hydrocarbons content in propane equivalent	0 - 8.1 %
3	Sulphur content	< 30 mg/m^3
4	Appliance pre-pressure	20 - 30 mbar
5	H_2 (molar)	< 10 %
6	O_2 (molar)	< 0.5 %
7	CO_2 (molar)	< 10.5 %
8	Relative density compared to air	< 0.8

Wobbe index
Because new appliances will also receive G gas with a (maximum) Wobbe index of 44.41 MJ/m^3 , at least up until the time when the entire appliance stock is able to handle gas with a higher Wobbe index, it seems obvious to notify this value as standard. A bandwidth of +2% and -2% can be adopted without problem. From the standard value of 44.41 MJ/m^3 the upper limit for the distribution value will be 45.3 MJ/m^3. Appliances in areas where only unmixed Groningen gas is expected to be distributed can be manually optimised during installation for the slightly lower Wobbe index of Groningen gas, 43.8 MJ/m^3.

Hydrogen (H_2) content
The passage about the hydrogen content in the future gas composition explains how a higher hydrogen content could be desirable for renewable energy, but because of uncertainty about this the maximum content is still being set at 0.5%.

In the even longer term it might be interesting to consider what the possibilities are for distributing higher levels of hydrogen content, probably regionally. In order to prevent consumers' appliances from then posing a restricting factor for such a development, the 'no regrets' measure could be implemented now by requiring that the appliances covered by Gas Appliances Directive must be able to cope with more hydrogen. The complete replacement of the consumers' appliance stock will take more than ten years, after all.

The extra costs are expected to be negligible or limited. The new appliances will be in the internationally widely used category I_{2E} for the high calorific setting. To be included in category I_{2E} appliances are tested with a light-back limit gas which contains hydrogen and in some cases with an overheating limit gas which contains hydrogen and propane. The same test is specified with regard to hydrogen for the low calorific setting.

A number of demonstrations and investigations have been carried out with higher hydrogen percentages. Some current generation domestic appliances, such as specific central heating boilers and cookers, were found to tolerate higher hydrogen content levels safely from a combustion point of view. It is anticipated that with modest modifications to the design the other domestic appliances can also be made suitable in combustion terms. What has received less attention is the lifespan of some components. Appliances must in principle be able to cope with 10% hydrogen for 15 years or more. This lengthy exposure is still unknown territory. For this reason it will have to be established that this can be done safely in practice on the basis of an appropriate practical test before the distribution of such a gas could be approved.

This is similar to the 'no regrets' measure which requires that appliances which are covered by the Gas Appliances Directive can be switched to a setting to use high calorific gas. This transition is not yet anticipated, but a 'no regrets' measure rules out fewer options for the more distant future.

Commencement date of the new requirements
As soon as the new gases have been notified, suppliers (installers) of appliances can be bound by the new requirements after a reasonable transfer period (grace period). Market forces can also play a role: a supplier who markets a future-proof appliance has an advantage over a supplier who continues to sell an appliance in the current $I_{2.L}$ category during the transfer period. Regarding this point, the proposal was made during the consultation to introduce a quality designation for future-proof appliances. This already exists: the appliance category must be easy to find and read on the appliance. The buyer will then know during the transfer period that every category other than $I_{2.L}$ which is allowed on the market in the Netherlands is definitely futureproof; an $I_{2.L}$ appliance may be suitable for the future G gas after the transfer,period but the $I_{2.L}$ label does not provide any certainty in this regard. Following the transitional period every available appliance sold will be future-proof.

Delivery pressure
During the consultation a lot of parties indicated that the Netherlands should not be the odd one out in the switch to the international H gas standard. This also applies to the aspect of the gas pressure at the location where the appliance is installed. The appliance pressure for the H gas setting will therefore be equal to the internationally accepted 17 to 25 mbar, often expressed as 20 mbar. It was pointed out in the consultation that this could lead to capacity problems in the regional distribution networks. But these capacity problems are not too serious, since high calorific gas also contains around 20% more energy per volume. This 20 mbar applies after the domestic pressure regulator. This means that the pressure before the domestic pressure regulator does not need to change, so that this decision has no consequences for the capacity of the networks which use a domestic pressure regulator. The regional network operators will have to take account of this over the coming decades. Thanks to the gradual decrease in gas consumption as a result of savings and the switch to energy sources other than gas (electrification) which has already started, there is no need to refrain from an international harmonisation because of this perceived problem. The domestic pressure regulators may have to be adjusted or replaced during the major operation which the switch from G to H gas involves.

CO_2
The CO_2 content of H gas can in theory be up to 10.5%. However, with such a CO_2 content it will be difficult to achieve the required Wobbe index for H gas. In addition to methane, the gas will then have to contain higher hydrocarbons. In upgrading green gas to H gas level, it is more logical to remove more CO_2 than to add higher hydrocarbons.

Switch from G to H gas
During the consultation a number of parties indicated that they would prefer to switch from the current G gas to H gas in one go. They do not want to receive G gas with a broader composition as an intermediate step. They particularly want to avoid the two switches taking place shortly after

one another. This is not likely. The ultimate switch to H gas is still a long way off. It is not yet being planned. However, the enrichment of the pseudo-G gas is already planned.
In addition, major consumers with a direct connection to the GTS network can investigate for themselves in consultation with GTS what the options are for switching from G gas consumption to H gas consumption. This has already taken place at 80 major consumers' connections over the past decades.