



BSI Standards Publication

Gas infrastructure — Quality of gas — Group H

National foreword

This British Standard is the UK implementation of EN 16726:2025. It supersedes BS EN 16726:2015+A1:2018, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GSE/33, Gas supply.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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European foreword

This document (EN 16726:2025) has been prepared by Technical Committee CEN/TC 234 “Gas infrastructure”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2026, and conflicting national standards shall be withdrawn at the latest by March 2026.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 16726:2015+A1:2018.

EN 16726:2024 includes the following significant technical changes with respect to EN 16726:2015+A1:2018:

- Inclusion of Wobbe index requirements in 5.1, Table 1, Wobbe index exit classification requirement (5.3), a Wobbe index entry recommendation (5.2) and related informative Annexes:
- Annex B – Limitations of the end-use gas applications to cope with the broad Wobbe index entry range;
- Annex C – Possible mitigation measures for Wobbe index changes;
- Annex D – General considerations on on-site adjustment of combustion processes and applications;
- Annex E – Current national Wobbe index requirements;
- Annex F – Rate of change of Wobbe index;
- Inclusion of the Calorific value in relationship to the Wobbe index (5.1, Table 1) and related informative Annex G
- Revision of the minimum relative density (5.1, Table 1);
- Addition of an admissible hydrogen concentration (5.1, Table 1) and related informative Annex K;
- Revision of the admissible sulfur content (5.1, Table 1) and addition of related informative Annex H;
- Revision of the admissible oxygen content (5.1, Table 1) and addition of related informative Annex I;
- Revision of the admissible methane number in this standard (5.1, Table 1) in relation to the general design of engines and addition of related informative Annex L.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

The need for a European Standard concerning the specification of the quality of gases of group H is derived from the standardization request M/400 issued to CEN by the European Commission.

According to this standardization request (dated back to 2007) and the more recent EU climate policies, the goal is to define specifications that are as wide as possible within reasonable costs. This means that the specifications enhance the free flow of gas within the internal EU market, in order to promote competition and security of supply minimizing the negative effects on gas infrastructure and gas networks, efficiency and the environment and allow appliances to be used without compromising safety.

Some requirements specified in this European Standard, Clause 5, cannot be implemented by

- Denmark
- Estonia
- Hungary
- Ireland
- Italy
- Romania
- The Netherlands

due to existing conflicting national legislation. The related A-Deviations are listed in Annex.

NOTE BSI announced the notification of A-Deviations for the requirements on Wobbe index Class specified (5.3.2), Oxygen (5.1, Table 1) and Hydrogen (5.1, Table 1) referring to Gas Safety Management Regulations, GSMR, for the UK gas supply being enforced in UK Law.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Introduction

This document sets requirements for gas quality with the aim to allow the free flow of gas between the CEN member states and to enable the security of supply taking into account the impact on the whole value chain from gas production and supply to end users.

The Wobbe index and oxygen requirements in this document are based on the proposal of the CEN Sector Forum Gas Joint Working Group Pre-normative studies of H-gas quality parameters (short: CEN SFGas Gas Quality Study, GQS).

NOTE Responsibility issues in the context of this document are subject to European or national regulations.

This document includes requirements on Wobbe index aspects which need an appropriate national/European framework as pre-condition for the implementation of the standard. This is expressed in Clause 5.3.6 Implementation of Wobbe index Classification.

Furthermore, this document does not define an acceptable rate of change (RoC) of Wobbe index as pre-normative work is needed; an informative Annex F is part of this document. A separate CEN process on RoC is intended to start in CEN/TC 234.

1 Scope

This document specifies gas quality characteristics, parameters and their limits, for gases classified as group H that are to be transmitted, injected into and withdrawn from storages, distributed and utilized.

NOTE For information on gas families and gas groups, see EN 437.

This document specifies a Wobbe index classification system which is applicable, if the corresponding national/European framework is available to support it.

This document does not give any threshold for the rate of change of Wobbe index or other gas quality parameters. Nevertheless, acknowledging the serious influence of the rate of change of Wobbe index and/or GCV on the proper functioning of a number of end-use applications, such as gas engines and gas turbines, the risks of the rate of change within the Wobbe index exit range is described in Annex F.

This document does not cover gases conveyed on isolated networks.

For specific requirements on the quality of biomethane and other renewable and low-carbon gases injected into the grid, reference is made to EN 16723-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 13443, *Natural gas - Standard reference conditions (ISO 13443)*

EN ISO 14532, *Natural gas - Vocabulary (ISO 14532)*

ISO 14912, *Gas analysis — Conversion of gas mixture composition data*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 14532 and the following apply.

NOTE Some legal definitions which are considered useful for the topic of this document are given in Annex M for information. Due to the normative character of this clause, they cannot be integrated here.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

isolated network

network where transmission, distribution and utilization of gas are combined and which is physically unconnected to other networks

3.2

application

installation or process that utilizes the transported and distributed gas

Note 1 to entry: Some examples of gas applications are: gas appliances (domestic or commercial), processes (chemical or industrial), turbines, engines, burners, etc.

3.3

sensitive applications/installations

applications/installations that need intervention to maintain the proper functioning due to the sensitivity towards one or more gas quality parameter values in the distributed gas including:

- integrity;
- safety;
- efficiency;
- emissions;
- performance (output/power)

3.4

system operator

private or public entity authorized to design, construct and/or operate and maintain a gas system

3.5

distributed gases

gases available at an exit point conveyed through the gas network

3.6

Wobbe index

W_s

ratio of the calorific value of a gas per unit volume and the square root of its relative density under the same reference conditions

Note 1 to entry: The Wobbe index is expressed in megajoules per cubic metre (MJ/m³) of dry gas under the reference conditions.

Note 2 to entry: The Wobbe index is said to be gross (W_s) or net (W_i) according to whether the calorific value used is the gross or net calorific value.

Note 3 to entry: Two fuel gases with the same Wobbe index will release the same amount of heat in a combustion system, as long as the nozzle pressure and the nozzle diameter remain constant. The gas temperature is assumed to remain constant in this context. The Wobbe index is the primary gas interchangeability criterion for residential and commercial appliances as well as for some large-scale combustion equipment in industry and power generation.

[SOURCE: EN 437:2021, 3.13, modified by adding NOTE 3 to entry]

3.7**Calorific Value****Gross calorific value****GCV**

value of heat that would be released in a complete combustion with oxygen of a given quantity of gas, whereby

- the pressure p_1 at which the reaction takes place remains constant and all combustion products are returned to the same given temperature t_1 of the original products;
- and all these products are in the gaseous state, with the exception of water, which condenses into the liquid state at temperature t_1

Note 1 to entry: The term net calorific value (NCV) is used when water is also present in a gaseous state after combustion. Pressure and temperature are usually related to the reference conditions (15 °C, 101,325 kPa).

3.8**entry (point)**

point – except interconnection points – at which gas enters a gas distribution or gas transmission system

Note 1 to entry: Underground storages are not considered as entry points.

3.9**exit (point)**

point at which gas leaves the gas transmission or gas distribution system for gas end-use

Note 1 to entry: Underground storages are not considered as exit point.

3.10**cluster of exit points**

homogeneous group of exit points which are considered as one exit point for the application of the Wobbe index classification system proposal

3.11**interconnection (point)**

physical point connecting adjacent gas transmission and distribution systems and/or storage systems

3.12**range**

values between maximum and minimum for a given gas quality property in absolute terms

3.13**bandwidth**

difference between a maximum and a minimum of a range

3.14**rate of change****speed of change****RoC**

change of the value of a gas quality property at a location per unit of time

Note 1 to entry: Nearly instantaneous change in local gas quality can be referred to as step change.

3.15

adjustment

setting a gas appliance or a gas application in such a way that the nominal operational process parameters (e.g. firing rate, air excess ratio, required process temperatures, emission values, safety) and expected lifetime of the system, as prescribed by the manufacturer, are met

Note 1 to entry: For residential and commercial appliances, this can be done with a reference gas like G20 (pure methane). For industrial and power generation equipment, the adjustment is usually part of the commissioning process and carried out with the locally available gas and the ambient conditions at the time of commissioning. This is called on-site adjustment.

3.16

gas blending

deliberate activity of mixing two or more separate gas streams for a specific purpose where a relevant fuel quality criterion (e.g. W_s or GCV) of the resulting gas blend is specified

Note 1 to entry: It takes place at specific locations in the network (e.g. a blending station)

3.17

mitigation measure

any measure in order to prevent or reduce significant adverse effects of gas quality changes

3.18

continuously experienced case

exit points or cluster of exit points experiencing the same Wobbe index range as they have been receiving for an extended period of time in the past

3.19

notice period

time between the announcement of the Wobbe index change to the end-user and the moment when the switch effectively takes place

3.20

combustion reference conditions

specified temperature T and pressure p at which a fuel is notionally burned

[SOURCE: EN ISO 14532:2017, 2.6.1.1]

3.21

metering reference conditions

specified temperature T and pressure p at which an amount of fuel to be burned is notionally determined

Note 1 to entry: There is no a priori reason for the metering reference conditions to be the same as the combustion reference conditions.

[SOURCE: EN ISO 14532:2017, 2.6.1.2]

3.22

A-deviation

modification of, addition to or deletion from the content of an EN (and HD for CENELEC)

reflecting a national situation due to regulations the alteration of which is for the time being outside the competence of the CEN and/or CENELEC member

Note 1 to entry: Where standards fall under EC Directives or Regulations, it is the view of the Commission of the European Communities (OJ No C 59, 1982-03-09) that the effect of the decision of the Court of Justice in Case 815/79

Cremonini/Vrankovich (European Court Reports 1980, p. 3583) is that compliance with A-deviations is no longer mandatory and that the free movement of products complying with such a standard should not be restricted within the EC except under the safeguard procedure provided for in the relevant Directive or Regulation

[SOURCE: IR Part 2:2022, 2.16]

4 Reference conditions and pressure units

Unless stated otherwise, all volumes are given for the real dry gas at ISO standard reference conditions of 15 °C (288,15 K) and 1 013,25 mbar (101,325 kPa). Unless otherwise stated, all pressures are absolute pressures.

Whenever data on the volume, gross calorific value (GCV), energy and Wobbe index are communicated, it shall be specified under which reference conditions these values were calculated, as these are necessary to quantify the calorific properties (Wobbe index, Calorific Value) of a fuel.

NOTE 1 In the EU, two reference systems exist which are commonly used. EN ISO 13443 and EN ISO 14532 define the reference system with 15 °C as a combustion reference temperature and 15 °C for metering purposes with 1 013,25 mbar as reference pressure, with energy contents given in MJ/m³, whilst many other documents and national and or European regulations use a reference system with 25 °C as a combustion reference temperature and 0 °C for volume (also with 1 013,25 mbar as reference pressure). Calorific properties, e.g. CV or W_s , can be given as kWh/m³ as well.

In assessing compliance with this European Standard, parameters should be determined directly at ISO standard reference conditions. If the properties are only available at other reference conditions and the actual gas composition is not known then conversion to ISO standard reference conditions shall be carried out using the procedure described in EN ISO 13443.

NOTE 2 The use of the reference condition 15 °C/15 °C as given in EN ISO 13443 is in line with the standardization request M/400. Besides the ISO standard reference conditions, particular in gas transmission, normal reference conditions (25 °C/0 °C) are used according to the Network Code Interoperability and Data exchange.

5 Requirements

5.1 Requirements to the gas quality

Gas shall comply with the requirements given in Table 1.

The gas shall not contain constituents other than listed in Table 1 at levels that prevent its transportation, storage and/or utilization without quality adjustment or treatment.

Table 1 — Requirements

Parameter	Unit	Limits based on standard reference condition 15 °C/15 °C		Reference standards for test methods ^e (informative)
		Min.	Max.	
Wobbe index	MJ/m ³ kWh/m ³	See subclauses 5.2 and 5.3 and Annex B to Annex F		EN ISO 6976
Calorific value (informative)	MJ/m ³	The calorific value results from the relationship between Wobbe index and relative density, see Annex G.		

Parameter	Unit	Limits based on standard reference condition 15 °C/15 °C		Reference standards for test methods ^e (informative)
		Min.	Max.	
Relative density ^a	no unit	0,45	0,70	EN ISO 6976, EN ISO 15970
Total sulfur	mg/m ³	not applicable	20 ^b without odorant	EN ISO 19739
	For existing practices with respect to transmission of odorized gas directly between high pressure networks a maximum sulfur content of 30 mg/m ³ shall apply. NOTE 1 Odorization is considered as a safety issue, dealt with at national level. Some information about sulfur odorant content is given in Annex H.			
Hydrogen sulphide + Carbonyl sulphide (as sulfur)	mg/m ³	not applicable	5 ^b	EN ISO 6326-3, EN ISO 19739
Mercaptan sulfur without odorant (as sulfur)	mg/m ³	not applicable	6 ^b	EN ISO 6326-3, EN ISO 19739
Sulfur from other components without odorant (as sulfur)	mg/m ³	not applicable	9	
Oxygen	No unit (as mole fraction)	not applicable	1 % or below 1 % to 0,01 % or below 0,01 % to 0,001 %, according to assessment process (see below)	EN ISO 6974-3, EN ISO 6974-6, EN ISO 6975

Parameter	Unit	Limits based on standard reference condition 15 °C/15 °C		Reference standards for test methods ^e (informative)
		Min.	Max.	
	In the gas infrastructure the concentration of oxygen shall be no more than 1 %. However, if it can be demonstrated by an assessment process that a gas with oxygen content can flow to installations with proven sensitivity to oxygen at the level:			
	— of below 1 % to 0,01 %, the maximum limit shall be lowered to the maximum acceptable limit, expressed as a moving 24-h-average.			
	— of below 0,01 %, the maximum limit shall be limited to 0,001 % at the lowest, expressed as a moving 24-h average. Solutions for protecting these specific installations shall be defined in co-operation of the parties concerned, as part of the assessment.			
	NOTE 1 Most applications can accept a level of 0,01 % of oxygen or higher; certain types of underground storages are sensitive to oxygen contents higher than 0,001 %.			
	On a case-by-case basis, it can be required to identify the techno-economical optimal solution enabling the level of O₂ acceptable for the part of the gas grid affected, e.g. from biomethane producers to installations sensitive to O₂.			
	The assessment process for identification of installations sensitive to O₂, and evaluation of the applicable threshold and responsibilities need to be stipulated to facilitate the application of the standard requirement on O₂ content.			
	NOTE 2 Considering the expected development of biomethane production, the lower maximum limit of 0,01 % will probably have to be reassessed upwards in the coming years.			
	NOTE 3 1 % is equal to 10000 ppm and 0,001 % is equal to 10 ppm.			
	More information on oxygen origin, challenges, mitigation measures and measurement are given in Annex I.			
Carbon dioxide	no unit (as mole fraction)	not applicable	2,5 % or 4 % (see below)	EN ISO 6974 parts 1 to 6, EN ISO 6975
	The mole fraction of carbon dioxide shall be no more than 2,5 % in case of operating pressures higher or equal to 16 bar and up to 4 % for operating pressures below 16 bar. However, where the gas can be demonstrated not to flow to installations sensitive to higher levels of carbon dioxide, e.g. underground storage systems, a higher limit of up to 4 % may be applied for pressures higher than 16 bar.			
Hydrocarbon dew point ^{c,d} at any pressure from 0,1 MPa to 8,5 MPa (85 bar) absolute pressure	°C	not applicable	-2	EN ISO 23874, ISO/TR 12148
Water dew point ^{c,d} at 7 MPa (70 bar).	°C	not applicable	-8	EN ISO 6327, EN ISO 18453, EN ISO 10101 parts 1 to 3
	If the grid is at a different pressure from 7 MPa, the resulting dew point temperature shall be converted to the equivalent of 7 MPa. For further information see Annex J. NOTE 4 Water dew point at 70 bar of -8 °C is equivalent to the water concentration of approximately 39 mg/m ³ depending on the gas composition.			
Hydrogen	no unit (as mole fraction)	not applicable	2 %	None

Parameter	Unit	Limits based on standard reference condition 15 °C/15 °C		Reference standards for test methods ^e (informative)
		Min.	Max.	
	A hydrogen concentration shall be accepted up to two percent by mol across the whole value chain. It may deviate nationally, regionally or locally for higher values than 2 mol/mol of hydrogen concentration provided that the requirements of the applications sensitive to hydrogen are met for lower values than 2 mol/mol of hydrogen concentration in case of proven sensitivity of installations to hydrogen, e.g. some underground gas storage and some gas turbines. For further information reference is made to 5.4 and Annex K.			
Methane number	no unit	70 or 65 (see below)	not applicable	Annex A
	NOTE 5 At the time of writing this document, the vast majority of gases have a <i>MN</i> above 70. For exemptions the minimum <i>MN</i> of 65 applies. Some exemptions are South Arne gas, gases from LNG terminals and possibly natural gas hydrogen blends, This limit value of 65 does not imply that gas engines must be designed for the minimum Methane Number (<i>MN</i>) of 65. They are generally designed for a minimum <i>MN</i> of 70 or above (see Annexes A and L).			

^a An approval of the legal weights and measurement regulation is necessary in some European countries.

^b Figures are indicated without post-comma digits due to analytical uncertainty.

^c Under given climatic conditions, a higher water dew point and hydrocarbon dew point may be accepted at national level.

^d For further information on water dew point and hydrocarbon dew point, see Annex J.

^e Test methods other than those listed in the reference standards indicated in Table 1 may be applied, provided their fitness for purpose can be demonstrated.

Gas quality shall not impede safety of gas appliances and operations of end users. Appropriate measures shall be taken.

NOTE 6 Applications are sensitive towards variations of the gas quality depending on the type of application and the degree of variation.

5.2 Entry point Wobbe index range (recommendation)

The Wobbe index entry range should be within 46,44 MJ/m³ and 54,00 MJ/m³ [15 °C/15 °C] (see Table 2).

Table 2 — Wobbe index entry range recommendation

Parameter	Unit	Limits based on standard reference condition 15 °C/15 °C	
		Min.	Max.
Wobbe index at entry points	MJ/m ³	46,44	54,00

NOTE 1 The Wobbe index limit values at entry points need to comply with the national requirements on the Wobbe index entry range.

NOTE 2 The Wobbe index entry range (B, 5.2) has been worked out in the CEN SFGas GQS [2][5]. It corresponds to the Wobbe index range of the EASEE-gas CBP 2005-001/02 [1].

NOTE 3 At exit points, a Wobbe index range/variation as large as this entry range can lead to safety, emission and performance issues in end-use applications. For further related information on the limitation of end-use applications to the broad Wobbe index range and the on-site adjustment see Annex D. Consequently, the Wobbe index classification at exit point applies as in 5.3.

5.3 Exit point Wobbe index classification

5.3.1 Definition of classes

The distributed gases at an exit point (or a cluster of exit points) shall be classified in classes according to 5.3.2 and 5.3.3.

A class shall be assigned to the exit point (or to a cluster of exit points), based on the expected Wobbe Indices at this point. Assignment is recommended to be based on both, historical data and data on future expectations, if available.

The lower and upper limits of the Wobbe index range shall be clearly indicated. The class shall be maintained for a maximum possible duration of time.

The Wobbe index of the distributed gas can exceed the Wobbe index limit values of the range of the class (see 5.3.5). Time, extent, frequency and impact of exceedance of the limit values of the given class shall be kept at a minimum.

NOTE 1 The Wobbe index limit values need to comply with the national requirements on the Wobbe index.

Awareness shall be given that the majority of nowadays applications (including residential and commercial) are not able to accept gas with a Wobbe index varying over the whole proposed entry range (46,44 MJ/m³ to 54,00 MJ/m³) covering a bandwidth of 7,56 MJ/m³ (see Annex B).

Available historical Wobbe index data shall be provided to end users requesting it.

NOTE 2 The Network Code Interoperability and data exchange (2015/703) deals with the data exchange with end-users in Art. 17 'Information provision on short-term gas quality variation'.

It is recommended to consider mitigation measures. Possible mitigation measures are collected in Annex C.

Once a Wobbe index class has been attributed to an exit point, end-users can expect the Wobbe index to remain in the defined class range as long as they are not contacted for a class change.

NOTE 3 It is expected that the requirements for the procedures needed to specify classes and to enable an implementation of the classification system will be dealt with in national/European legislation.

5.3.2 Class Specified

Class Specified shall be assigned to exit points (or to a cluster of exit points) for the distributed gases if the following conditions apply:

- Wobbe index bandwidth of $\leq 3,7$ MJ/m³;
- within the Wobbe index range of 46,44 MJ/m³ to 53,00 MJ/m³ [15 °C/ 15 °C at 1 013,25 mbar].

The downstream sectors and relevant end-users shall be informed about the defined classification including:

- the lower and upper Wobbe index limit values;

- with a bandwidth of 3,7 MJ/m³ within the range of 46,44 MJ/m³ to 53,00 MJ/m³.

Exceeding the upper and lower limits of the defined class Wobbe index values (deviations) can occur (see 5.3.5). In that case, the necessary information covered in 5.3.5 shall be communicated.

NOTE 1 For some types of end-use equipment significant technical measures (e.g. CEN Sector Forum Gas – Gas Quality Study Report on Wobbe index 2021 [2]; German Hauptstudie Gasbeschaffenheit [3][4]) will be needed to fulfil all safety, operational and legal requirements, even with a Wobbe index bandwidth of 3,7 MJ/m³. It would be preferable that all future end-use equipment can accept the bandwidth of 3,7 MJ/m³.

5.3.3 Class Extended

Class Extended shall be assigned to exit points (or a clusters of exit points) for distributed gases which are not covered by the Class Specified within the recommended Wobbe index entry range of 46,44 MJ/m³ to 54 MJ/m³ (5.3) or within the national Wobbe index specification for H-gas (see Annex E).

NOTE 1 In many countries national legal Wobbe index ranges exist, which can differ from the recommended Wobbe index entry range; in other countries generally acknowledged national standards and/or codes of practices apply.

Allocating Class Extended to exit points (or clusters of exit points) requires

- unbiased assessment of the presence of users' applications sensitive to Wobbe index at the concerned exit point or cluster of exit points and,
- if any, the implementation of appropriate mitigating measures in cooperation with all parties involved (Annex C).

If a Class Extended allocated to a specific exit point (or to a cluster of exit points) is proven by confirmation with historical data to be a continuously experienced case (see 3.18), then no assessment for the presence of applications sensitive to Wobbe index is needed. This can also apply for exit points (or for a cluster of exit points) having the same application technologies as in another area with continuously experienced gas quality variations (demonstrated by initial assessment).

Attention shall be given to required safety margins.

The lower and upper Wobbe index limit values shall be defined per exit point within the Wobbe index entry range.

Exceeding the upper and lower limits of the defined class Wobbe index values (deviations) can occur (see 5.3.5). In that case, the necessary information covered in 5.3.5 shall be communicated.

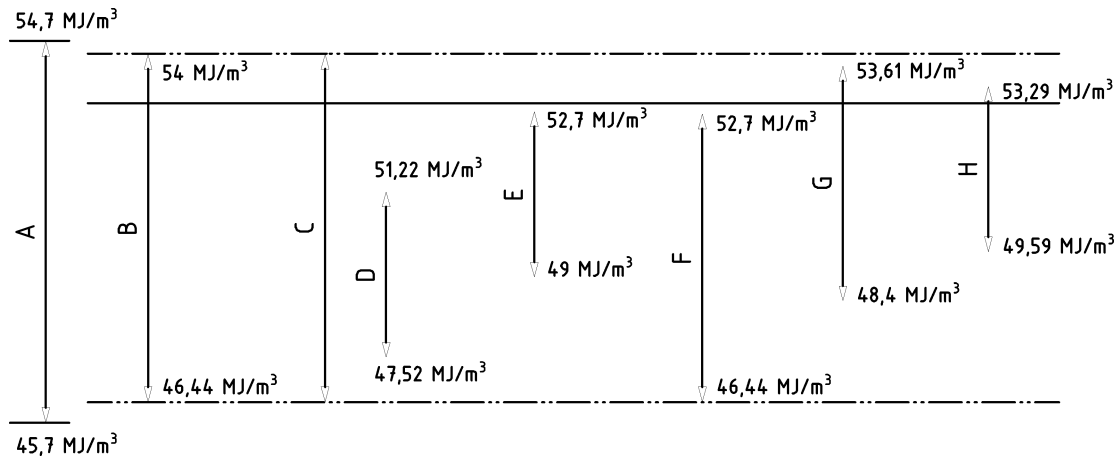
Downstream sectors and relevant end-users shall be informed about the classification system and the assigned class including the defined values and the necessary information covered in 5.3.5 in case of deviation from the allocated class.

NOTE 2 A Wobbe index range – covering a bandwidth of 7,56 MJ/m³ – is not compatible with on-site adjustment of end-use settings to the local gas quality (Annex D). Many applications can be adjusted, but sometimes require additional physical changes to the equipment.

5.3.4 Examples of classes

5.3.4.1 General

Examples of classes are visualized in Figure 1; Concrete examples for Class Specified and for Class Extended are described below.



Key

- A EN 437, Test gases range for H-gas appliances (given here for reference)
- B Wobbe index range recommendation at entry point (5.2)
- C Upper Wobbe index limit of Class Specified – 53 MJ/m³
- D Exit 1 (Class Specified)
- E Exit 2 (Class Specified)
- F Exit 3 (Class Extended as bandwidth > 3,7 MJ)
- G Exit 4 (Class Extended as bandwidth > 3,7 MJ)
- H Exit 5 (Class Extended as upper $W_s > 53$ MJ/m³)

NOTE 1 For more information on the Wobbe index entry range and the Wobbe index classification see Clauses 5.2 and 5.3.

Figure 1 — Example of assigned Wobbe index classes – specified and extended – to some exit points

5.3.4.2 Example of Class Specified

Potential situation, as is depicted by example D above (5.3.4., Figure 1):

- the actual distributed gases in exit point D have a Wobbe index bandwidth of 3,7 MJ/m³; the gas quality data over a certain period of time (to be determined) obtained for exit point D shows Wobbe index values comprised within 47,52 MJ/m³ and 51,22 MJ/m³ (corresponding to the 3,7 MJ/m³ Wobbe index bandwidth); The Class Specified has a fixed bandwidth of 3,7 MJ/m³, whereas the actual distributed gases in an exit point in a Class Specified might have a Wobbe index range below or equal to 3,7 MJ/m³. This is to ensure that the class limits given for this exit point stay true for as long as technically possible (same class, same lower and upper Wobbe index values);
- according to the classification system, exit point D is in a Class Specified.

Potential information given to the end-users connected to exit point D:

- classification: the customers' gas application receives gas from an exit point in a Class Specified;
- indication of the foreseen lower Wobbe index value of 48,0 MJ/m³ and the foreseen upper Wobbe index of 51,7 MJ/m³, i.e. a Wobbe index bandwidth of 3,7 MJ/m³.

NOTE The described example presumes a recognized procedure for classification and communication.

5.3.4.3 Example for Class Extended

The following potential situation covers the situation within the recommended Wobbe index entry range and does not take into account a possibly existing broader national legal entry range. It is not describing the situation of continuously experienced cases.

Potential situation, as is depicted by example F above (5.3.4, Figure 1):

- the actual distributed gases in exit point F have a Wobbe index bandwidth of 6,26 MJ/m³;
- the gas quality data over a certain period of time (to be determined in the process) obtained for exit point F show Wobbe index values comprised between 46,44 MJ/m³ and 52,7 MJ/m³ (corresponding to the 6,26 MJ/m³ Wobbe index bandwidth);
- in the classification, system exit point F is in a Class Extended.

Potential information given to the end-users connected to exit point F:

- classification: the customers' gas application receives gas from an exit point in a Class Extended;
- indication of the foreseen lower Wobbe index limit value of 46,44 MJ/m³ and the foreseen upper limit value of 52,7 MJ/m³, i.e. a Wobbe index bandwidth of 6,26 MJ/m³;
- if the end-use application is identified as sensitive to Wobbe index variations, indication of a warning remark.

Stakeholders involved are cooperating for the unbiased assessment of the presence of sensitive applications/installations:

- to identify the sensitivity of the end-use applications;
- to perform an impact analysis in order to identify which mitigation measures, if needed, are the most reasonable.

Inclusion of other parties, such as the equipment manufacturer, in the process might be needed.

5.3.5 Deviation from a defined class

In case of deviations from the class limits, two situations can appear:

a) Short-term temporary deviation (i.e. temporary Wobbe index excursions):

Downstream sectors or relevant end-users shall be informed of deviations as soon as information is available that the Wobbe index is going outside of the class ranges. This change can be a predictable or unexpected deviation.

Stakeholders involved should cooperate to identify the appropriate mitigation measures to limit the impact of the temporary deviation.

b) Long-lasting or permanent deviation resulting in a possible class change:

- Downstream sectors and/or relevant end-users shall be informed of upcoming long lasting or permanent Wobbe index changes; in case of short-notice deviations, information shall be forwarded without delay.
- An assessment of the consequences of the change of class in cooperation with the stakeholders involved shall be carried out.

In the case of an extended class, the assessment can be combined with the requested assessment in 5.3.3.

- The downstream sectors or relevant end-users shall be informed about the assignation of the new class with an appropriate notice period.

NOTE 1 A class can change to another Class Specified or to another Class Extended or from a Class Specified to a Class Extended or vice versa.

This change is usually predictable.

NOTE 2 The procedure related allocation of classes and deviations will be defined in national/European legislation.

5.3.6 Implementation of Wobbe index classification

The Wobbe index classification system in this document shall apply, if the corresponding national/European framework is available to support it.

At least the assessment procedure for identification of applications sensitive to Wobbe index, the assignation and change of classes, related time scales and responsibilities need to be stipulated to enable an implementation of the classification system.

5.4 Effects of the injection of hydrogen onto gas quality

In case of injection of hydrogen, the resulting hydrogen/natural gas blend shall meet all the requirements given in this document with respect to both, combustion properties (i.e. Wobbe Index, rel. density) and trace impurities (i.e. oxygen, sulfur, etc.).

5.5 Sampling

Determination of parameters in Table 1 is based on representative samples of gas. Guidance is provided by EN ISO 10715.

Annex A

(normative)

Calculation of methane number of gaseous fuels for engines

A.1 Introduction

The methane number of a gaseous fuel can be calculated from its composition according to several different methods, all of which can give different results. For the purposes of compliance with this European standard the methodology described in this annex shall be employed.

The method (MNC) is based on the original data of the research program performed by AVL Deutschland GmbH or FVV e.V. / Sience for a moving society (the Research Association for Combustion Engines) but employs amendments implemented in 2005 and 2011 by MWM GmbH. These amendments have been unpublished until the publication of this European Standard.

The method requires input of composition in the form of volume fractions at reference conditions of 0 °C and 101,325 kPa and expressed as a percentage. Composition is more likely to be available either as mole fraction (e.g. in the natural gas transmission and distribution industry) or as mass fraction (e.g. in the automotive fuel industry) and, if needed, conversion to volume fraction shall be performed using the methods in ISO 14912.

Numerical examples are provided so as to enable software developers to validate implementations of the methodology described in this annex. As an aid to validation a relatively large number of decimal places has been retained. For expression of the final result rounding to zero decimal points is recommended.

NOTE It is in discussion to delete this annex as soon as the (EN) ISO 17507-1 (The MNC method) is available (expected end 2025).

A.2 Calculation of methane number

A.2.1 Applicability

The method described in this European Standard is applicable to gaseous fuels comprising the following gases: carbon monoxide; butadiene; butylene; ethylene; propylene; hydrogen sulphide; hydrogen; propane; ethane; butane; methane; nitrogen and carbon dioxide. The method treats hydrocarbons other than those specified as butane and is therefore applicable to gaseous fuels containing such higher hydrocarbons.

The numerical examples provided in this annex are appropriate to gases of the second family and hence consider mixtures comprising methane, ethane, propane, butane, nitrogen and carbon dioxide. Hydrogen is also included in one example because of the growing interest in injection of hydrogen into gas pipelines. During the preparation of this standard MWM GmbH has confirmed that the method is applicable to both 2H and 2L gases.

Oxygen and water vapour shall be ignored, and the fuel gas composition shall be calculated on a dry, oxygen-free basis.

A.2.2 General approach

The methane number of a gaseous fuel is calculated from its composition in five steps. The steps are outlined below and discussed more fully in turn in A.3. Additional examples are discussed in A.4 and A.5. Table A.10 provides results of calculations for further software validation purposes.

- a) The composition of the gaseous fuel is simplified by converting it into an inert-free mixture comprising the combustible compounds carbon monoxide, ethylene, propylene, hydrogen sulphide, hydrogen, propane, ethane, butane and methane.

For gases of the second family conveyed in pipeline systems carbon monoxide, ethylene, propylene, hydrogen sulphide are unlikely to be present at concentrations that would impact on methane number and can be ignored.

- b) The simplified mixture is sub-divided further into a number of partial ternary mixtures. The number and particular partial ternary mixtures chosen is decided by inspection of available ternary systems in a given order, including those systems that contain the relevant combustible compounds. Selection is ceased when all combustible compounds are contained in at least two ternary systems.
- c) The composition and fraction of the selected partial mixtures is adjusted iteratively so as to minimize the difference between the methane numbers of each partial mixture.
- d) The methane number of the simplified mixture is determined from the weighted average of the methane number of the selected partial mixtures.
- e) Finally, the methane number of the gaseous fuel is calculated by correcting the methane number of the simplified mixture to allow for the presence of inerts in the original fuel gas.

A.3 Example 1: 2H-gas

A.3.1 Simplification of the composition of the gaseous fuel

The description of the calculation is illustrated by reference to a 2H-gas of composition shown in Table A.1. The composition of the gas (column 1) is simplified by increasing the quantity of butanes to allow for the presence of butadiene, butylene, pentanes and hydrocarbons of carbon number greater than 5. The adjustment made is as follows:

- Butadiene and butylene are replaced with an equivalent amount of butanes by multiplying their quantities by 1.
- Pentanes are replaced with an equivalent amount of butanes by multiplying the quantity of pentanes by 2,3.
- Hydrocarbons of carbon number greater than 5 ("hexanes+") are replaced with an equivalent amount of butanes by multiplying the quantity of hexanes+ by 5,3.

In the case of example 1 the quantity of butanes

$$= 0,210\ 0 + 0,190\ 0 + (0,040\ 0 + 0,050\ 0) \times 2,3 + 0,060\ 0 \times 5,3$$

$$= 0,925\ 0 \text{ (Column 2)}$$

The simplified mixture is then re-normalized to 100 % (Column 3).

A.3.2 Selection of the ternary systems

A.3.2.1 Ternary mixtures

The ternary mixtures are chosen from the following list:

- A1: Methane – Hydrogen – Ethane
- A2: Propane – Ethane – Butane
- A3: Hydrogen – Propane – Propylene
- A4: Methane – Ethane – Propane
- A5: Methane – Hydrogen – Propane
- A6: Methane – Hydrogen – Butane
- A7: Methane – Propane – Butane
- A8: Methane – Ethane – Butane
- A9: Methane – Ethylene – Butane
- A10: Methane – Hydrogen Sulphide – Butane
- A11: Methane – Ethane – Hydrogen Sulphide
- A12: Methane – Propylene
- A13: Ethane – Propylene
- A14: Carbon Monoxide – Hydrogen
- A15: Ethane – Ethylene
- A16: Propane – Ethylene
- A17: Butadiene
- A18: Butylene

NOTE Mixtures A12 to A16 are clearly not ternary systems; however, for ease of mathematical treatment the coefficients have been adjusted so as to allow the expression of the methane number using a single equation.

A.3.2.2 Range of applicability of ternary mixture data

The range of applicability of most ternary systems is wide (each component can vary from 0 % to 100 %). However, for some ternary systems there is a reduced range of applicability. This is a major issue when selecting ternary mixtures. The range of applicability of each ternary system is specified in Table A.2, expressed as maximum and minimum content of each component.

A.3.2.3 Factors affecting the ternary system selection process

The ternary systems are selected in accordance with three main considerations:

- a) The number of gases in the ternary system that are present in the simplified mixture. Priority is always given to ternary systems that have all three of their components present in the simplified mixture. Systems with two of their components present in the simplified mixture are acceptable if insufficient systems with three components present in the simplified mixture are available.
- b) Where there is a choice of ternary systems, the system with the highest fitness, W_j , takes priority.
- c) Each component in the simplified mixture shall be represented in at least two ternary systems.

Fitness of a system is calculated from the following formula:

$$W_j = \sum_{i=1}^n \frac{V_{i,\min(100, (V_{\max_{i,j}} + 15))}}{V_{\text{sum}_i}} \quad (\text{A.1})$$

where

- n is the number of components in the simplified mixture;
- V_i is the volume fraction of component i in the simplified mixture;
- $V_{\max_{i,j}}$ is the maximum content of component i for the range of applicability of system j ;
- V_{sum_i} is the sum of all maximum contents of component i for the range of applicability of all systems, i.e.

$$V_{\text{sum}_i} = \sum_{j=1}^{j=18} \min(100, (V_{\max_{i,j}} + 15)) \quad (\text{A.2})$$

Values of V_{sum_i} are independent of the composition of the simplified mixture. However, W_j is dependent upon the composition of the simplified mixture and so shall be calculated prior to selection. Note that this also means that the choice of ternary mixtures may be different for mixtures containing the same components, but in different proportions.

In the case of example 1, the calculation of V_{sum_i} and W_j is shown in Table A.3 and Table A.4.

A.3.2.4 Description of the ternary system selection process

The aim is to identify the optimum number of ternary systems that meet the three criteria described in A.3.2.3 and this is achieved by consideration of each component present in the simplified mixture in the following sequence:

- 1) Carbon Monoxide
- 2) Butadiene
- 3) Butylene
- 4) Ethylene
- 5) Propylene
- 6) Hydrogen Sulphide
- 7) Hydrogen

- 8) Propane
- 9) Ethane
- 10) Butane
- 11) Methane

Step 1: For the first component in the simplified mixture, one ternary system that contains that component is selected. The priority of selection is as follows:

- a) Ternary systems with all three components present in the simplified mixture have priority over systems having one or two components present.
- b) The ternary mixture with the highest fitness has priority.

Step 2: Consideration is then given to the second component in the simplified mixture. If this component is not present in the ternary system selected for the first component, then a ternary system is selected for this component using the same priority of selection as in step 1. If, however, the ternary system selected for the first component contains the second component, then the selection proceeds for the third component (step 3).

Step 3: Consideration is then given to third, fourth, fifth, etc. components in the same manner as Steps 1 to 2.

Step 4: When all components in the simplified mixture have been examined once, steps 1 to 3 are repeated in the same component order. If any component is represented in only one selected ternary mixture, then an additional ternary mixture is selected, again using the same priority of selection as in step 1.

The selection process ends when all components in the simplified mixture are represented in at least two ternary systems.

In the case of example 1:

- *The first component in the simplified mixture is propane and this is present in four ternary systems that have all their components present in the simplified mixture – A2, A4, A7 and A8. In this case, A4 is selected because it has the largest value of fitness (i.e. 10,3138).*
- *The second component in the simplified mixture is ethane and this is already represented in system A4, so no ternary mixture is selected.*
- *The third component of the simplified mixture, butane, is not represented in system A4, so system selection continues and system A8 is selected because it has the highest value of fitness (10,2859).*
- *The fourth component in the simplified mixture is methane and this is already represented in systems A4 and A8, so no ternary mixture is selected.*
- *Selection is repeated with the first component in the simplified mixture, propane, and ternary system A7 is selected because it has the next highest value of fitness (9,6263; system A4 has already been selected).*

All components in the simplified mixture are now represented in at least two of the ternary systems selected and the selection process ends. The systems selected are therefore: A4, A7 and A8.

A.3.3 Sub-division of the inert-free mixture into the selected partial mixtures

The simplified mixture is divided into the selected partial ternary mixtures. A preliminary division of the simplified mixture is made by assigning each component equally between the ternary systems in which it is represented.

In the case of example 1, three ternary systems – A4, A7 and A8 – are selected. The preliminary division is made by assigning: methane equally between A4, A7 and A8; ethane equally between A4 and A8; propane equally between A4 and A7; and butanes equally between A7 and A8 (Columns 4, 6 and 8).

A.3.4 Calculation of the methane number of the partial mixtures

The methane number of each partial mixture is calculated from the general formula

$$MN_t = \sum_{i=0}^{i=7} \sum_{j=0}^{j=6} (a_{i,j} x^i y^j) \quad (\text{A.3})$$

Where x and y are the volume fractions of the first and second components in each partial ternary mixture, expressed as a percentage. In order to calculate the methane number of each partial mixture, therefore, the composition of each is normalized to 100 %.

In the case of example 1 the composition of each partial mixture is calculated by renormalizing to 100 % (Columns 5, 7 and 9).

Table A.2 lists the values of coefficients $a_{i,j}$ for the partial ternary systems A1 to A18.

In the case of example 1 application of Formula (A.3) for each preliminary composition of partial mixture results in calculated methane numbers of 76,248 9, 77,377 7 and 71,970 6 for A4, A7 and A8 respectively (Columns 5, 7 and 9).

A.3.5 Adjustment of the composition and fraction of the partial mixtures

The composition and fraction (F_t) of each partial mixture is adjusted iteratively by varying the quantity of each component in each partial mixture so as to minimize the difference between the methane numbers of each partial mixture.

The value to be minimized is therefore:

$$(MN_{\max} - MN_{\min}),$$

where $MN_{\max}$ and $MN_{\min}$ are the maximum and minimum methane numbers for the selected partial mixtures.

In the case of example 1, three ternary partial mixtures are selected and hence there are nine quantities to be determined, however four of these may be obtained by material balance considerations.

$$N_{\text{A8, methane}} = N_{\text{methane}} - N_{\text{A4, methane}} - N_{\text{A7, methane}}$$

$$N_{\text{A8, ethane}} = N_{\text{ethane}} - N_{\text{A4, ethane}}$$

$$N_{\text{A7, propane}} = N_{\text{propane}} - N_{\text{A4, propane}}$$

$$N_{\text{A8, butane}} = N_{\text{butane}} - N_{\text{A7, butane}}$$

Where $N_{t, \text{comp}}$ is the quantity of the respective component in partial mixture t .

The composition and fraction of each partial mixture is therefore performed by adjustment of five quantities: the quantities of methane, ethane and propane in A4, and the quantity of methane and butane in A7.

During adjustment the volume fraction of any component in any partial mixture shall be within the range for which the coefficients of Formula (A.3) are valid. Table A.2 lists the ranges of validity.

The problem of adjusting the composition and fraction of each partial mixture is therefore a constrained minimization one and in principal any appropriate numerical procedure may be employed. For the examples described in this annex, the Solver supplied with Microsoft Excel (using default settings) produces an acceptable solution.

Depending upon the ending criterion of the numerical method employed, slight differences in the value of $(MN_{\max} - MN_{\min})$ will result in slightly different values of methane number of the simplified mixture. In addition, the use of different starting values for the composition and fraction of each partial mixture will result in slightly different values of methane number of the simplified mixture. These differences are within the uncertainties of this method and it is recommended that the final value of methane number is rounded to zero decimal places before reporting.

In the case of example 1, the composition and fraction of partial mixtures is provided in Table A.5 (Columns 4 to 9). For clarity, the five adjusted quantities are shown in underlined text.

A.3.6 Calculation of the methane number of the simplified mixture

The methane number of the simplified mixture is determined from the weighted average of the methane number of the relevant partial ternary mixtures:

$$MN' = \sum_{t=1}^{t=N_{\text{sys}}} (MN_t \cdot F_t) \quad (\text{A.4})$$

where

- MN' is the methane number of the simplified mixture;
- MN_t is the methane number of partial mixture t ;
- F_t is the fraction of the partial mixture t ;
- N_{sys} is the number of ternary systems selected.

In the case of example 1, this results in a methane number of the simplified mixture of $MN' = 74,901.8$.

A.3.7 Calculation of the methane number of the gaseous fuel

The methane number of the gaseous fuel is calculated by correcting the methane number of the simplified mixture to allow for the presence of inerts in the original fuel gas:

$$MN = MN' + MN_{\text{inerts}} - MN_{\text{methane}} \quad (\text{A.5})$$

In the original work of AVL/1/ MN_{inerts} is the methane number of a methane-carbon dioxide-nitrogen mixture having the same inerts content as that of the original mixture. However, in the amendment of MWM the MN_{inerts} is calculated for a methane-carbon dioxide-nitrogen mixture containing only carbon dioxide and methane. MN_{methane} is calculated for a methane-carbon dioxide-nitrogen mixture containing pure methane and is equal to 100,000.3.

The methane number of the methane-carbon dioxide-nitrogen mixture is calculated using Formula (A.3). Table A.2 lists the appropriate coefficients (system A20).

In the case of example 1, the methane-carbon dioxide-nitrogen mixture comprises methane (97,875.0 volumes, the sum of the volumes of combustible components in the simplified mixture), nitrogen (1,040.0 volumes) and carbon dioxide (1,460.0 volumes) (Table A.5, column 10), which is normalized to a nitrogen-free mixture comprising methane (98,530.2 % vol/vol) and carbon dioxide (1,469.8 % vol/vol) (Table A.5, column 11). Application of Formula (A.3) results in a methane number of $MN_{\text{inerts}} = 101,420.1$.

Application of Formula (A.5) results in a methane number of the gaseous fuel of

$$74,901\ 8 + 101,420\ 1 - 100,000\ 3 = 76,332\ 17$$

The value of methane number is reported as 76.

A.4 Example 2: enriched biomethane

A.4.1 Simplification of the composition of the gaseous fuel

This example illustrates the calculation for a biomethane derived from anaerobic digestion that has been enriched by addition of propane. The composition is shown in Table A.6.

In the case of example 2 the quantity of butanes

$$= 0,146\ 1 + 0,029\ 2 \times 2,3 + 0,000\ 0 \times 5,3$$

$$= 0,213\ 3 \text{ (Column 2)}$$

The simplified mixture is then re-normalized to 100 % (Column 3).

A.4.2 Calculation of fitness of the ternary systems

Application of Formula (A.1) to example 2 results in the values of W_j shown in Table A.7.

A.4.3 Selection of ternary mixtures

The first component in the simplified mixture is propane and this is present in ternary systems that have all their components present in the simplified mixture – A2, A4, A7 and A8. In this case, A7 is selected because it has the largest value of fitness (10,665 2).

The second component in the simplified mixture is ethane and this is not represented in system A7, so system selection continues and system A4 is selected because it has the highest value of fitness (10,638 0).

The third and fourth components of the simplified mixture are represented in system A7 (butane and methane) and A4 (methane) so the selection process restarts.

The selection process is repeated with the first component in the simplified mixture (propane), which is already represented in selected systems A4 and A7.

Selection continues with the second component in the simplified mixture (ethane), which is represented in only one selected system (A4), so system A8 is selected because it has the next highest value of fitness (9,050 8).

All components of the simplified mixture are represented in at least two systems and so selection ends. The systems selected are therefore: A4, A7 and A8.

A.4.4 Calculation of the methane number

After preliminary division of the simplified mixture the calculation of methane number according to the methods in A.3.3 to A.3.7 the methane number of the gaseous fuel of example 2 is shown in Table A.5. Again, for clarity, the five adjusted quantities are shown in underlined text. The value of methane number obtained (69,033 6) is reported as 69.

A.5 Example 3: 2H-gas with hydrogen addition

A.5.1 Simplification of the composition of the gaseous fuel

This example illustrates the calculation for the 2H-gas of composition of example 1 to which hydrogen has been added. The composition is shown in Table A.8.

In the case of example 3 the quantity of butanes