



BSI Standards Publication

Petroleum industry and
products — Determination
of composition of refinery
heating gas and
calculation
of carbon content and
calorific value — Gas
chromatography method

National foreword

This British Standard is the UK implementation of EN 15984:2011.

The UK participation in its preparation was entrusted to Technical Committee PTI/15, Natural Gas and Gas Analysis.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© BSI 2011

ISBN 978 0 580 63809 1

ICS 75.160.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2011.

Amendments issued since publication

Date	Text affected
<hr/>	

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 15984

April 2011

ICS 75.160

English Version

**Petroleum industry and products - Determination of composition
of refinery heating gas and calculation of carbon content and
calorific value - Gas chromatography method**

Industries et produits pétroliers - Détermination de la
composition des gaz combustibles de raffinerie, de leur
pouvoir calorifique et de leur teneur en carbone - Méthode
par chromatographie en phase gazeuse

Mineralölindustrie und -produkte - Bestimmung der
Zusammensetzung von Heizgas für Raffinerien und
Berechnung des Kohlenstoffgehaltes und des Heizwertes -
Gaschromatographisches Verfahren

This European Standard was approved by CEN on 9 March 2011.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Contents

Page

Foreword	3
1 Scope	4
2 Principle	4
3 Reagents and materials	4
4 Apparatus	5
5 Gas chromatographic analysis	6
5.1 Analysis systems	6
5.2 System configuration	6
5.3 Columns	6
6 Calibration	7
6.1 General	7
6.2 Absolute response factors	7
6.3 Relative response factors	7
7 Calculation	8
7.1 General	8
7.2 Calculation of the non normalized mole fractions	8
7.3 Validation of normalized composition (reference components)	8
7.4 Calculation of carbon content	9
7.5 Calculation of lower calorific value, on mass basis	10
8 Expression of results	10
9 Precision	10
9.1 General	10
9.2 Repeatability	11
9.3 Reproducibility	11
10 Test report	11
Annex A (informative) Possible column combination	12
Annex B (normative) Detector linearity check	17
Annex C (informative) Calculation test data	19
Annex D (normative) Data for calculation	20
Bibliography	21

Foreword

This document (EN 15984:2011) has been prepared by Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”, the secretariat of which is held by NEN.

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 October 2011, and conflicting national standards shall be withdrawn at the latest by October 2011.

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

This document is based on a DIN Standard [3] with the same scope.

According to the CEN/CENELEC Internal Regulations, the national standards organizations 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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard defines a gas chromatographic analysis for the determination of the composition of fuel gases, as used in refinery heating gas. These results are used to calculate the carbon content and the lower calorific value.

With this gas chromatographic analysis, an overall of 23 refinery heating gas components are determined in concentrations as typically found in refineries (see Table 1 for further details).

Water is not analysed. The results represent dry gases.

NOTE 1 Depending on the equipment used, there is a possibility to determine higher hydrocarbons as well.

NOTE 2 For the purposes of this European Standard, the terms “% (V/V)” is used to represent the volume fraction (φ).

IMPORTANT — This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations.

2 Principle

This standard defines a procedure that is used to determine all components that are present in a typical refinery heating gas, as indicated in Table 1.

NOTE The composition range in which each component can be analyzed does depend on the actual sample composition as higher amounts of a certain component may affect the detection range of other components eluting close by. The general ranges which apply to all the individual components are:

Hydrocarbons from 0,01 (mol/100 mol) up to 100 (mol/100 mol);

Non-condensable gases from 0,02 (mol/100 mol) up to 100 (mol/100 mol);

For hydrogen sulfide a range between 0,1 (mol/100 mol) up to 10 (mol/100 mol) has been found applicable.

Three different analysis systems are necessary; they may be built in three separate gas chromatographs, or be integrated into one.

Depending on the configuration, hydrocarbons with more than five carbon atoms are reported as a sum parameter. The composition of the refinery heating gas is used to calculate the carbon content and the calorific value. A typical procedure is described hereafter. A configuration is acceptable when the determination gives the precision as described in Clause 9.

3 Reagents and materials

3.1 Gases.

3.1.1 **Hydrogen**, with a minimum purity of 99,995 % (V/V).

3.1.2 **Helium**, with a minimum purity of 99,995 % (V/V).

3.1.3 **Nitrogen**, with a minimum purity of 99,995 % (V/V).

3.1.4 **Air**, free of oil and water.

3.1.5 **Argon**, as alternative for analysis system 2, with a minimum purity of 99,995 % (V/V).

5 Gas chromatographic analysis

5.1 Analysis systems

The gas chromatographic system consist of the following three parts:

1) Analysis system 1

All components except hydrogen (see Table 1) are retained on a porous polymer and a molecular sieve column and back flushed.

NOTE HayeSep® and Molsieve® are examples of such commercially available columns.

Hydrogen is determined on a TCD with nitrogen (3.1.3) as the carrier gas (see Figure A.4).

2) Analysis system 2

The second analysis system separates non-condensable gases, carbon dioxide, and hydrocarbons with two carbon atoms and hydrogen sulfide with helium (3.1.2) as the carrier gas and a TCD as a detector. After a pre-separation on a porous polymer column (column 3) propane and higher hydrocarbons are back flushed and vented. See Figure A.5 for details..

When the inert gases (O₂/Ar, N₂, CH₄ and CO) are on the molecular sieve 13X column, this column is isolated. Carbon dioxide, the C₂-hydrocarbons and hydrogen sulfide are eluted from the porous polymer column (column 4) and are detected. The C₂-hydrocarbons from this fraction are not used for quantification. After this the molecular sieve 13X column (column 6) is eluted and the components are determined on the TCD. Methane is quantified on Analysis System 3.

3) Analysis system 3

The third analysis system separates and quantifies all hydrocarbons by an FID and hydrogen (3.1.1) or helium (3.1.2) as the carrier gas. Two columns are used in series. From the methyl silicone column (column 1), the components above a certain cut point e.g. *n*-pentane are back flushed and determined as a summed peak. The hydrocarbons from the alumina oxide column, column 2, are then separated and quantified. See Figure A.6 for details.

5.2 System configuration

The gas chromatographic system may consist of one or more gas chromatographs, with the possibility for isothermal or temperature programmed runs or both depending on the selected system configuration. A TCD and an FID shall be available.

A gas flow control system and gas sampling valves and switching valves are used.

Means for quantification shall be provided.

NOTE Optionally a vaporizer may be used.

5.3 Columns

A combination of packed and capillary columns is possible.

It shall be ascertained that a quantitative separation of all the components that need to be determined (see Table 1) is possible and that the summed total of C₅₊ is quantitative. Adequate separation is required between the components on all three separation systems.

If cyclopropane can be determined, it shall be summed to propene.

An example for a typical configuration is given in Annex A.

6 Calibration

6.1 General

Depending on the production procedure of the reference gas mixture, it might be necessary to convert the concentration units of the components in the calibration gas to (mol/mol) %.

Linearity of the detectors shall be checked according to Annex B.

If calibration is necessary, e.g. daily or for an analysis series, a reference gas mixture shall be analysed. For each analysis system (see 5.1) at least one component, the reference component, needs to be calibrated. For example, for analysis system 1 hydrogen, for analysis system 2 nitrogen and for analysis system 3 propane. With these three components, an external calibration is done. The absolute response factor is calculated.

For all the other components, relative response factors will be used (see 6.3).

The relative response factor of the reference component will be set at 1,0.

As alternative all absolute response factors can be determined for all the components that need to be analyzed in a reference gas mixture. A check of this calibration can take place with a gas mixture with fewer components.

6.2 Absolute response factors

The determination of absolute response factors is possible when a repeatable injection is possible under constant analysis conditions. The ratio between concentration and peak area is determined and the absolute response factor is calculated with the following equation:

$$RF_i = \frac{x_i}{A_i} \quad (1)$$

where

RF_i is the absolute response factor of component i ;

x_i is the concentration of component i in (mol/100 mol) in the calibration gas;

A_i is the peak area of component i in the calibration gas.

6.3 Relative response factors

For quantification relative response factors can be used too. In one analysis system, one component is used as a reference (reference component).

The relative response factor is calculated with the following equation:

$$RRF_i = \frac{RF_i}{RF_{St}} \quad (2)$$

where

RRF_i is the relative response factor of component i ;

RF_i is the absolute response factor of component i ;

RF_{St} is the absolute response factor of the reference component St .

7 Calculation

7.1 General

For the calculation of parameters of gas mixtures, as described in this standard, the molar composition of the gas mixture is necessary.

NOTE A more accurate result may be obtained by analyzing the C5 olefins separately and not adding them to the sum of all heavier components.

7.2 Calculation of the non normalized mole fractions

The concentrations of the components, $X_{i, sample}$, mentioned in Table 1 are calculated as mole fractions. The calculation of these follows Equation (3):

$$X_{i, sample} = A_{i sample} \times RRF_{i St} \times RF_{StK} \quad (3)$$

where

$A_{i sample}$ is the area of component i in the sample;

$RRF_{i St}$ is the relative response factor of component i relative to the reference component St ;

RF_{StK} is the absolute response factor of the reference component St in the reference gas mixture K .

NOTE If only absolute response factors are used, then reference component St and component i are identical. Therefore, in Equation (3) $RRF = 1$ and each RF represents the individual component i .

7.3 Validation of normalized composition (reference components)

The results can be normalized, when the sum of all the mole fractions of the components are not smaller than 0,98 or greater than 1,02. If not, the analysis should be repeated. If the duplicate analysis does not improve this result, the calibration and the apparatus shall be checked.

Normalization is done according to:

$$X_i = \frac{X_{i, sample}}{\sum_{i=1}^k X_{i, sample}} * 100 \quad (4)$$

where

X_i^* is the corrected concentration of component i in the sample in mol/100 mol;

$X_{i \text{ sample}}$ is the uncorrected concentration of component i in the sample;

$\sum_{i=1}^k x_{i \text{ sample}}$ is the sum of the non normalized mol fractions of the sample;

k is the number of components.

7.4 Calculation of carbon content

The determined and normalized concentrations of each component, calculated according to Equations (3) and (4) are independent of pressure and temperature. By multiplying the concentration of each component with their respective molar mass and normalizing the results, the (mol/100 mol) fractions are

W_i according to:

converted to (g/100 g) of gas,

$$W_i = \frac{x_i^* M_i}{\sum_{i=1}^k x_i^* M_i} \cdot 100 \quad (5)$$

where

x_i^* is the corrected concentration of the component i in the sample in (mol/100 mol);

M_i is the molar mass of the component i in g/mol;

$\sum_{i=1}^k (x_i^* M_i)$ is the sum of the normalized molar fractions of the sample multiplied by the molar mass;

k is the number of components.

The carbon content of the individual components, $W_{C,i}$, are given in Table D.1.

The calculation is according to Equation (6):

$$W_C = \frac{\sum_{i=1}^k n_i \cdot W_{C,i}}{\sum_{i=1}^k n_i}$$

$$C_i = \frac{n_{C_i} M_c}{M_i} \quad (6)$$

where

n_{C_i} is the number of carbon atoms in the component i ;

M_c is the molar mass of carbon in g/mol;

M_i is the molar mass of the component i in g/mol.

The sum of the values found by multiplication of the concentration w_i in (g/100g gas) with the molar carbon concentration

w_{C_i} of component i results in the carbon content of the mixture (g C/100g gas), C_c .

$$C = \sum_{i=1}^k w_i \times \frac{H_{ci}}{M_i} \quad (7)$$

7.5 Calculation of lower calorific value, on mass basis

The component concentration determined in 7.2 is independent of pressure and temperature. Multiplication with the molar mass in g/mol results in component quantity in grams. If the sum of the individual quantities is normalized to 100 g, then the component quantities are given in g/100 g gas.

For the conversion of the normalized mol fractions (7.3) in (g/100 g) of gas refer to 7.4.

The lower calorific values for the individual components in Table D.1 shall be used. The conversion in kJ/g is according to Equation (8):

$$H_{u,c} = \sum_{i=1}^k \frac{H_{ci}}{M_i} \times W_i \quad (8)$$

where

$H_{u,c}$ is the lower calorific value of component i in kJ/g;

H_{ci} is the lower calorific value of component i in kJ/mol;

M_i is the molar mass of component i in g/mol.

The sum of the values found by multiplication of the concentration W_i in (g/100 g gas) with the lower calorific value H_{ci} of each component i in kJ/mol results in the lower calorific value of the total mixture in (kJ/100 g gas).

$$H_{u,c} = \sum_{i=1}^k w_{xi} \times H_{ci} \quad (9)$$

$$i=1 \quad u$$

8 Expression of results

Report the carbon content in (g/100 g) of gas, to the nearest 0,01.

Report the calorific value in (kJ/100 g) of gas, to the nearest 0,01.

Report of the compositional analysis of the refinery heating gas in (mol/100 mol), to the nearest 0,01.

9 Precision

9.1 General

The precision given in 9.2 and 9.3 was determined by statistical examination of interlaboratory test results in accordance with EN ISO 4259 [1].

10

9.2 Repeatability

The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the values calculated from the following equation only in one case in twenty.

For the lower calorific value:

$$r = 0,004 * X \text{ (kJ/100 g)} \quad (10)$$

and for the carbon content:

$$r = 0,01 * X \text{ (g/100 g)} \quad (11)$$

where

X is the mean of the results being compared.

9.3 Reproducibility

The difference between two single and independent test results, obtained by different operators working in different laboratories on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the values calculated from the following equation only in one case in twenty.

For the lower calorific value:

$$R = 0,022 * X \text{ (kJ/100 g)} \quad (12)$$

and for the carbon content:

$$R = 0,022 * X \text{ (g/100 g)} \quad (13)$$

where

X is the mean of the results being compared.

10 Test report

The test report shall contain at least the following information:

- a) reference to this European Standard, i.e. EN 15984;
- b) type and complete identification of the product (sample) tested;
- c) result of the test (see Clause 7);
- d) any deviation, by agreement or otherwise, from the procedure specified;
- e) date of the test.

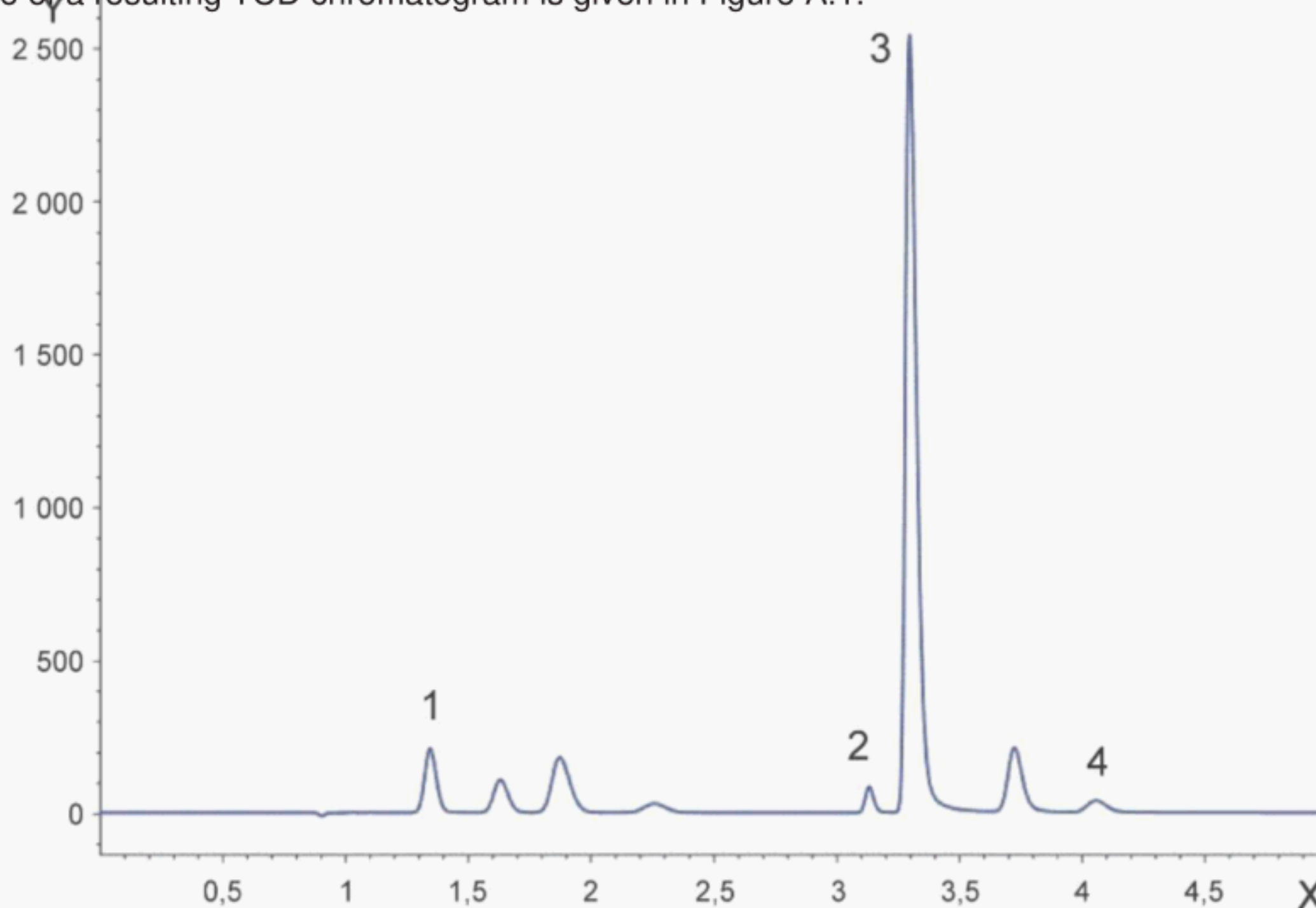
Annex A (informative)

Possible column combination

The following combination of columns may be used:

- Column 1 Pre column for hydrocarbons up to C6. Nominally 3 m x 320 µm methyl silicone.
- Column 2 Analysis column for hydrocarbons. Nominally 25 m x 320 µm aluminium oxide Plot.
- Column 3 Nominally 0,25 m of a porous polymer (e.g. HayeSep Q).
- Column 4 Nominally 1 m of a porous polymer (e.g. HayeSep N).
- Column 5 Nominally 2 m of a porous polymer (e.g. HayeSep Q) + Molsieve 5A. The two columns are combined in series with the porous column in front of the Molsieve column.
- Column 6 Nominally 2 m of Molsieve 13X.

An example of a resulting TCD chromatogram is given in Figure A.1.

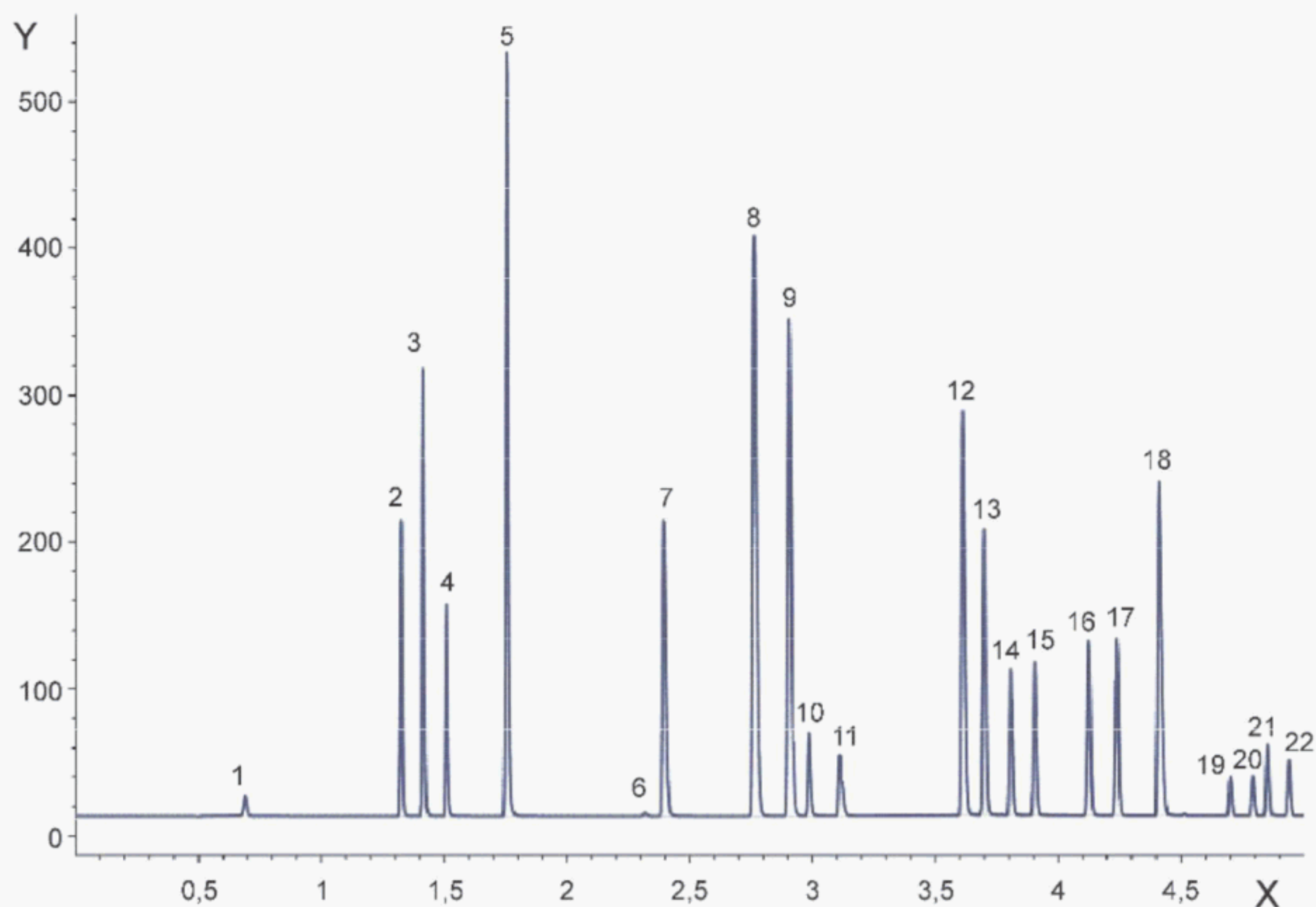


Key

- 1 carbon dioxide
- 2 oxygen
- 3 nitrogen
- 4 carbon monoxide
- X time (min.)
- Y output (µV)

Figure A.1 — Example of a TCD chromatogram of a reference gas

Methane, Ethane, Ethene and Acetylene are quantified by FID (see Figure A.2).

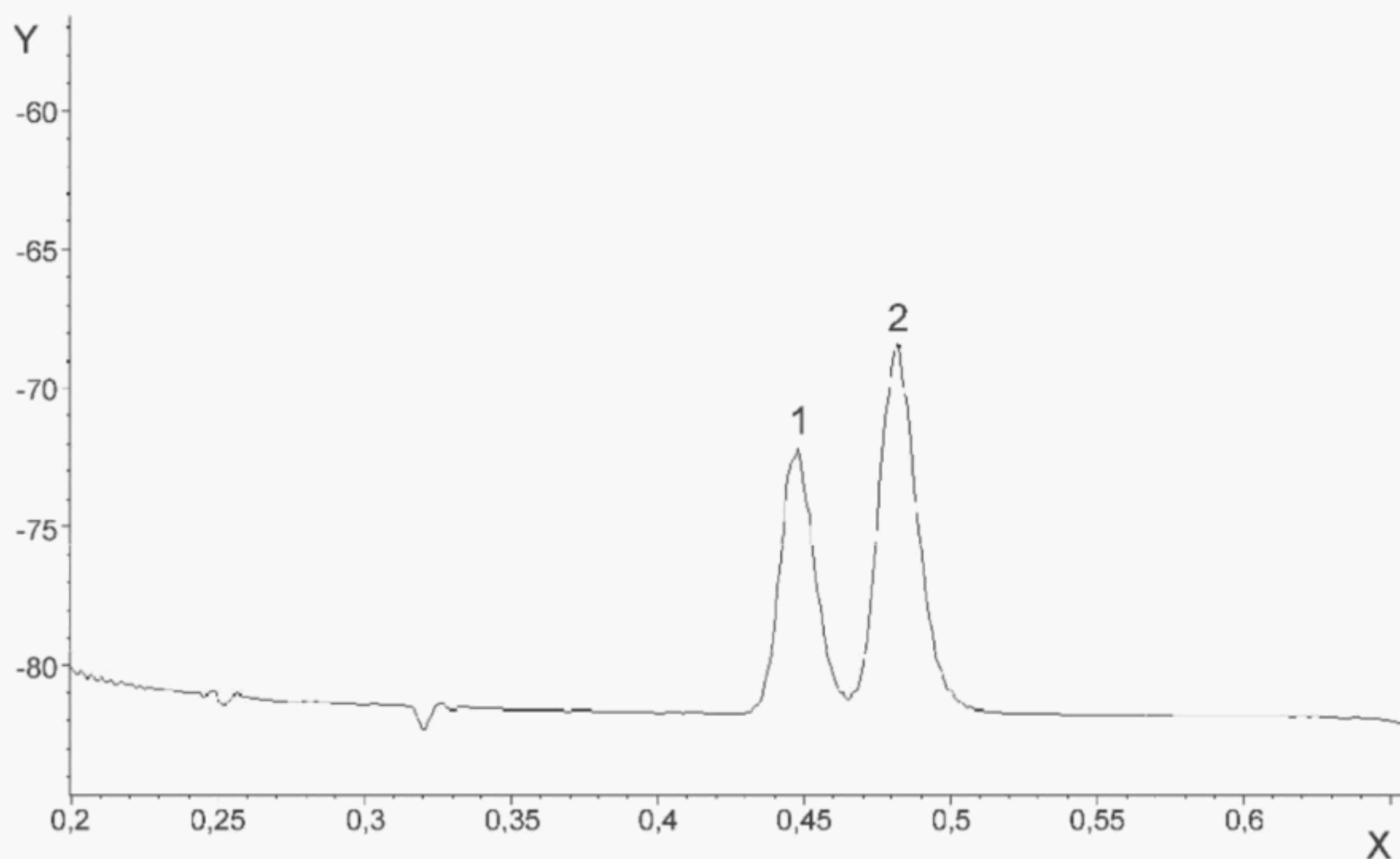


Key

1	C6+	10	propadiene	19	trans-2-pentene
2	methane	11	acetylene	20	2-methyl-2-butene
3	ethane	12	<i>trans</i> -2-butene	21	1-pentene
4	ethene	13	1-butene	22	<i>cis</i> -2-pentene
5	propane	14	<i>iso</i> -butene		
6	cyclopropane	15	<i>cis</i> -2-butene	X	time (min.)
7	propene	16	<i>iso</i> -pentane	Y	output (pA)
8	<i>iso</i> -butane	17	<i>n</i> -pentane		
9	<i>n</i> -butane	18	1,3-butadiene		

Figure A.2 — Example of a FID chromatogram of a reference gas

For the Hydrogen/Helium channel a chromatogram is given in Figure A.3.



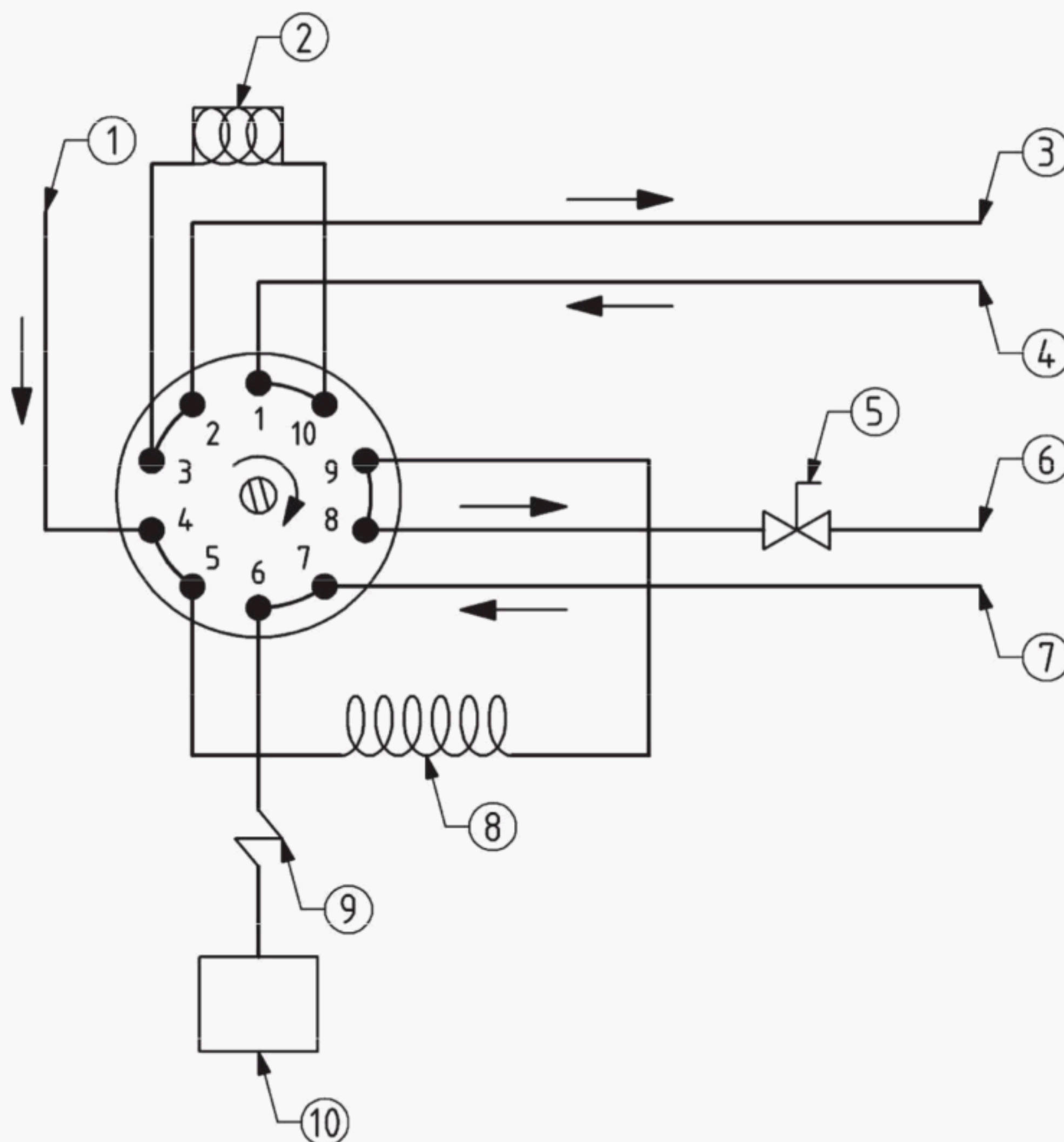
Key

- 1 helium
- 2 hydrogen

X time (min.)
Y output (μV)

Figure A.3 — Example of a H₂/He chromatogram

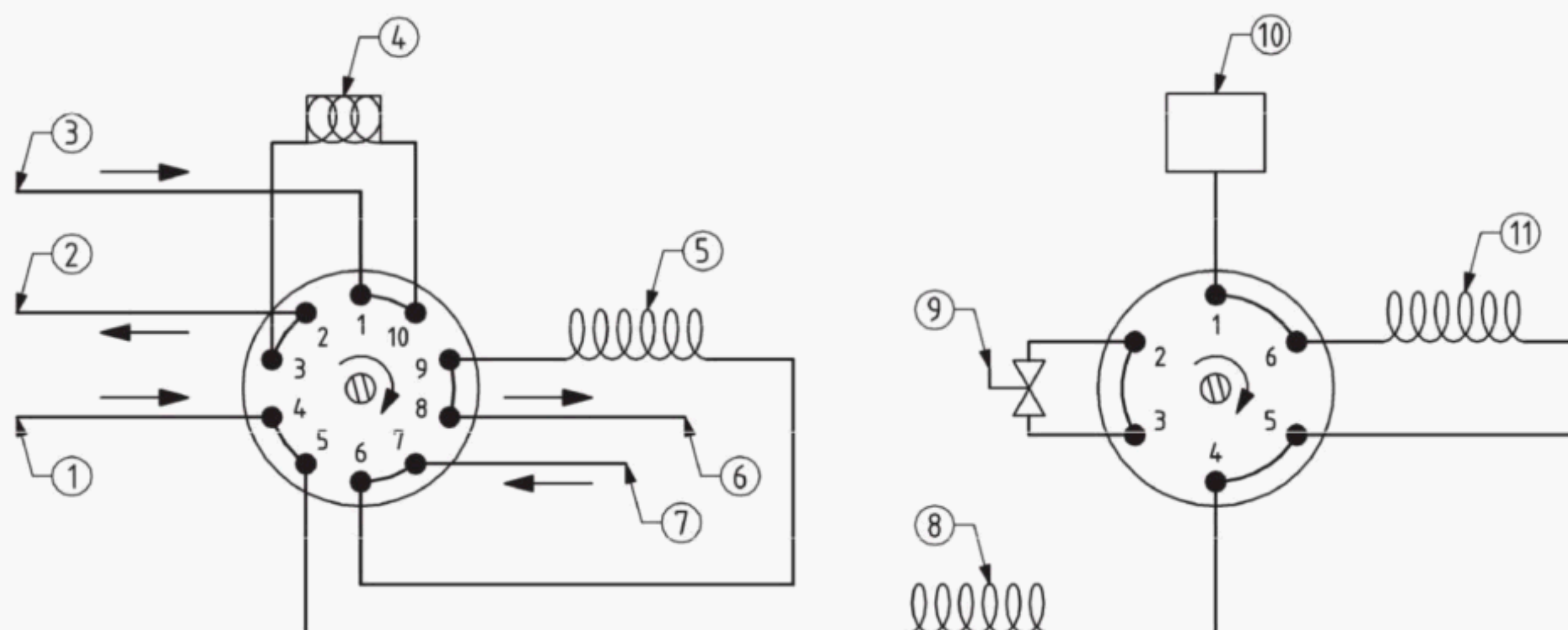
Details on the equipment for the testing of different components are given in Figures A.4, A.5 and A.6.



Key

- | | | | |
|---|------------------------|----|------------------------|
| 1 | carrier N ₂ | 6 | vent N ₂ |
| 2 | sample loop | 7 | carrier N ₂ |
| 3 | gas sample out | 8 | column 5 |
| 4 | gas sample in | 9 | fixed restriction |
| 5 | needle valve | 10 | TCD |

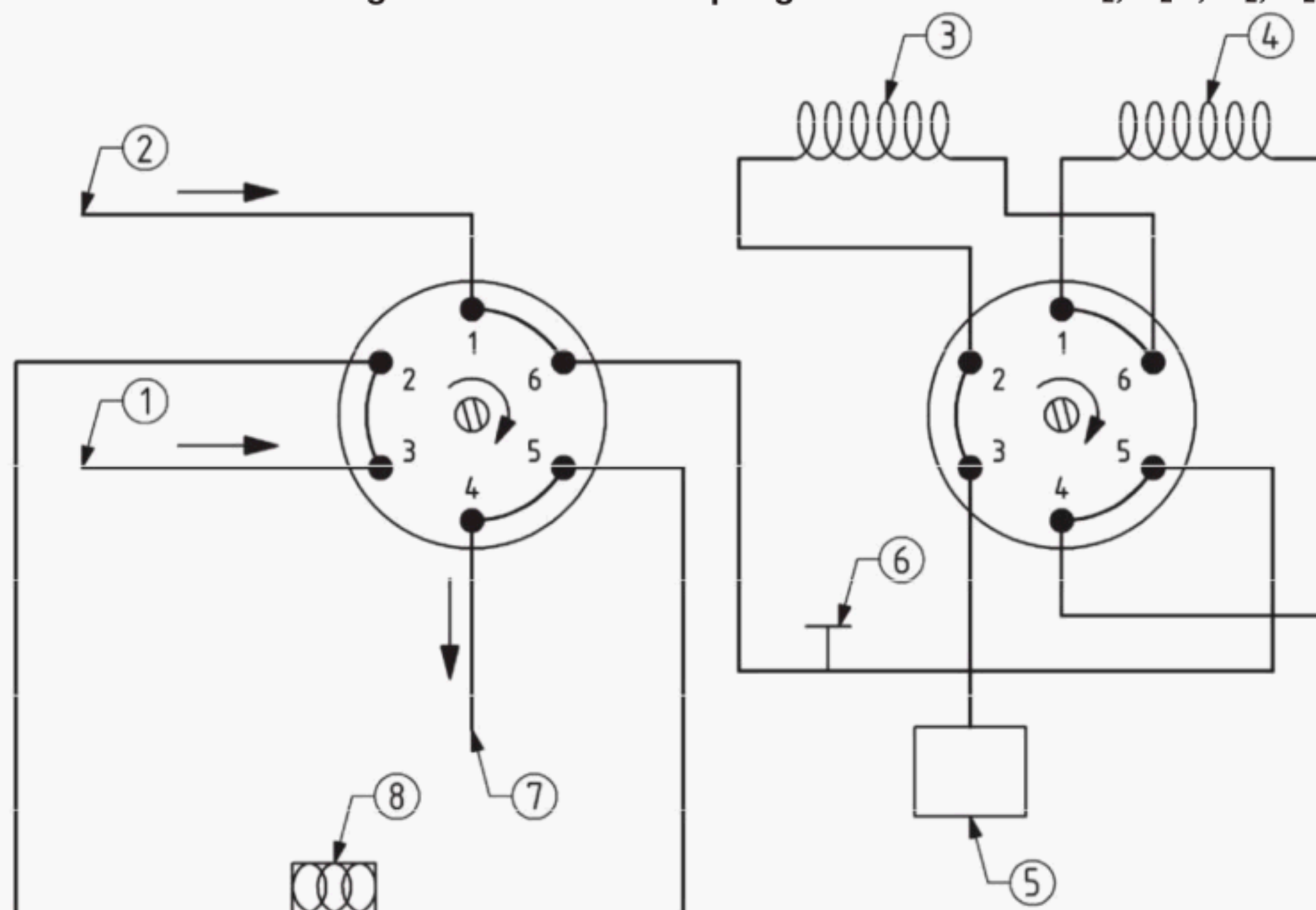
Figure A.4 — Valve configuration for the sampling and elution of He and H₂



Key

- | | | | |
|---|----------------|----|--------------|
| 1 | carrier | 7 | carrier |
| 2 | gas sample out | 8 | column 4 |
| 3 | gas sample in | 9 | needle valve |
| 4 | sample loop | 10 | TCD |
| 5 | column 3 | 11 | column 6 |
| 6 | vent He | | |

Figure A.5 — Valve configuration for the sampling and elution of CO₂, H₂S, O₂, N₂, CO and CH₄



Key

- | | | | |
|---|---------------|---|------------------|
| 1 | gas sample in | 5 | FID |
| 2 | carrier | 6 | Split/ Splitless |
| 3 | column 2 | 7 | gas sample out |
| 4 | column 1 | 8 | sample loop |

Figure A.6 — Valve configuration for the sampling and elution of the hydrocarbons

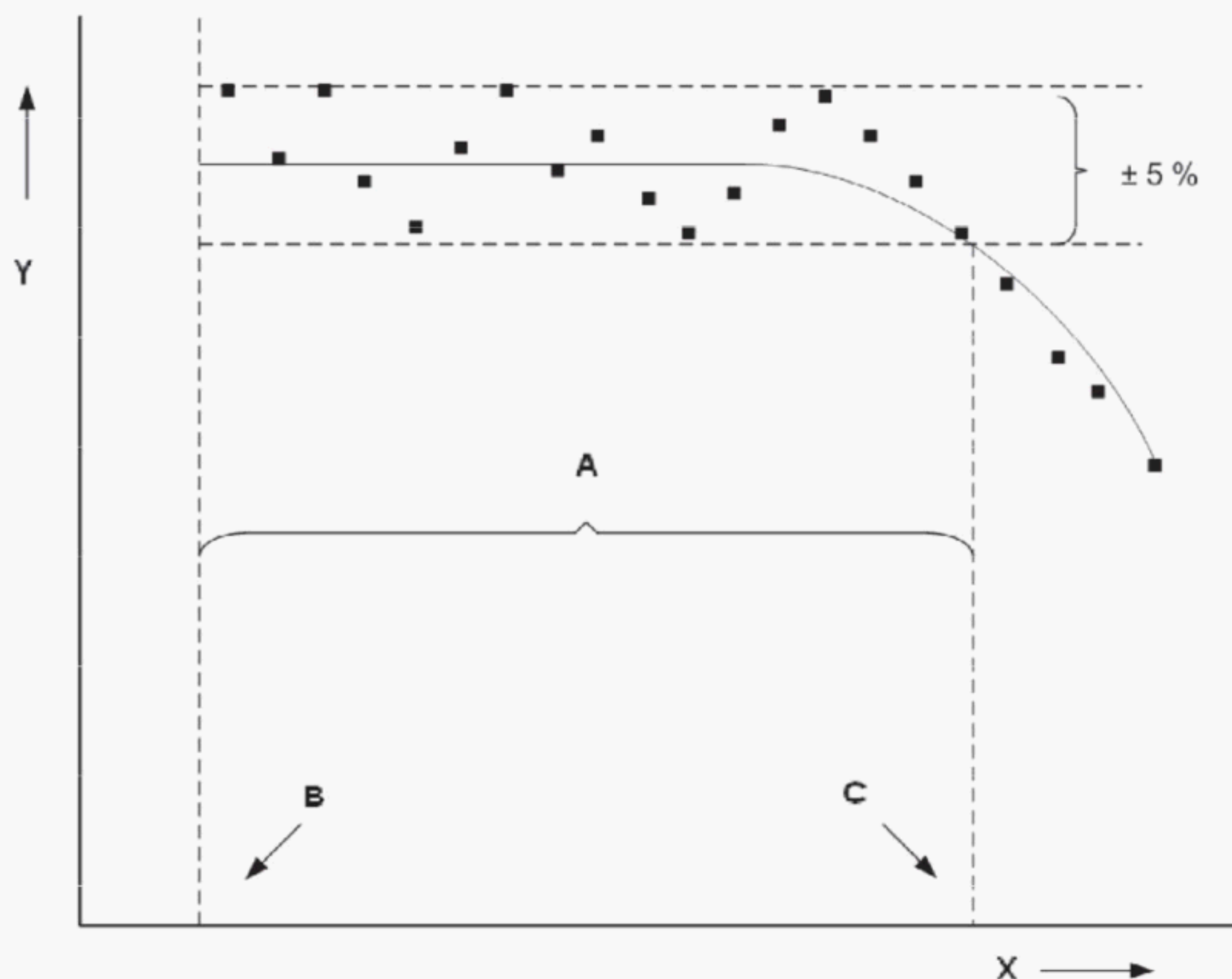
Annex B (normative)

Detector linearity check

The linear range of a chromatographic detector represents the range of concentrations or mass flows of a substance in the mobile phase at the detector over which the sensitivity of the detector is constant within a specified variation, usually $\pm 5\%$ relative.

NOTE The linearity check is derived from DIN 51405 [2].

The best way to present detector linear range is the linearity plot (see Figure B.1) plotting detector sensitivity against amount injected, concentration or mass flow-rate. Here, the upper limit of linearity can be graphically established as the amount (concentration, or mass flow-rate) at which the deviation exceeds the specified value. The lower limit of linearity is always the minimum detectable amount determined separately for the same compound.



Key

- A linear range
- B minimum detectability
- C upper limit linear range

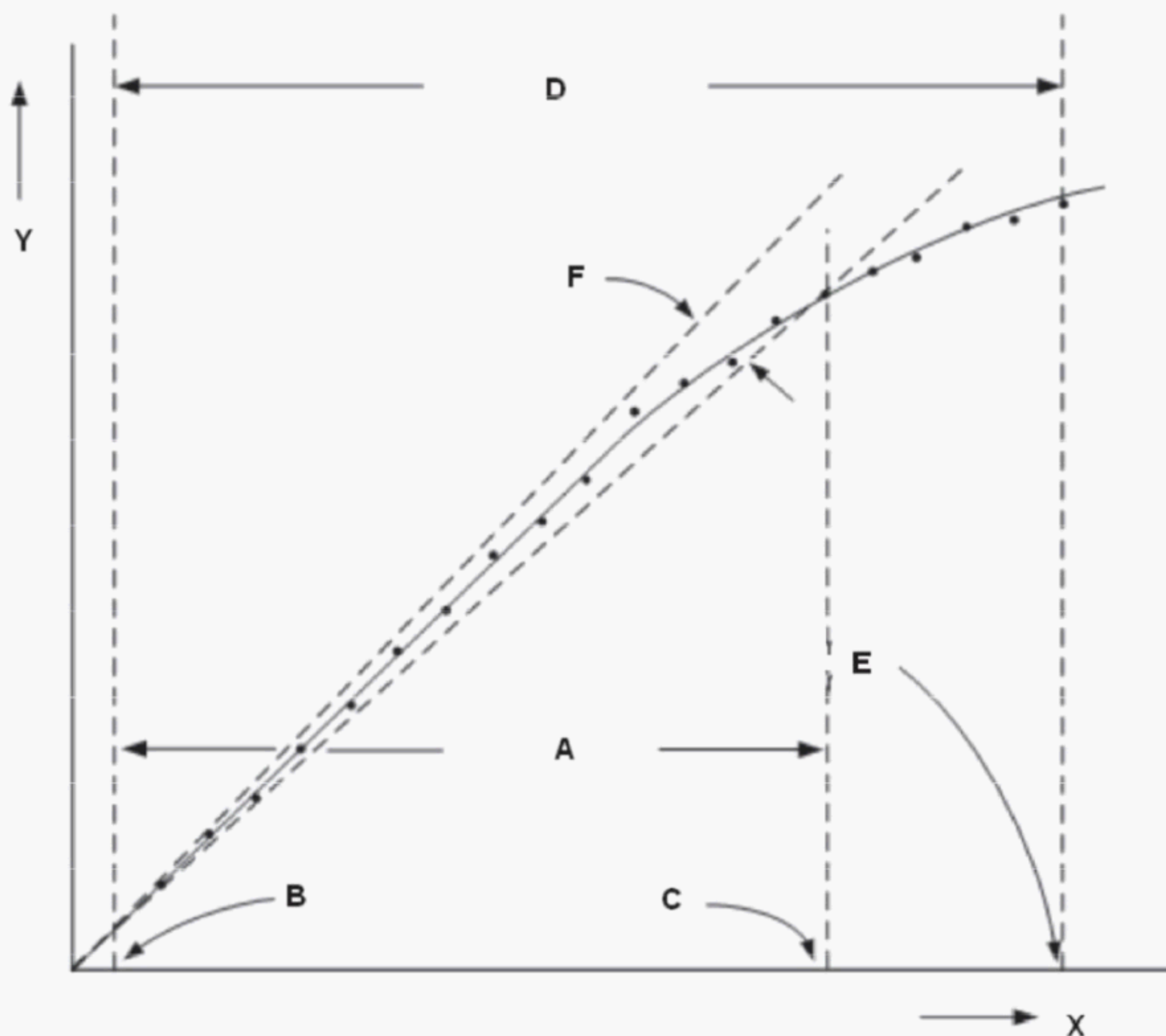
- X concentration or mass flow
- Y detector sensitivity

Figure B.1 — Linearity plot

Alternatively, the linear range of a detector may be presented as the plot of peak area (height) against concentration or mass flow-rate of the test substance in the column effluent at the detector (see Figure B.2). This plot may be either linear or log/log. The upper limit of linearity is that concentration (or mass flow-rate) at which the deviation from an ideal linearity plot is greater than the specified percentage ($\pm 5\%$).

Numerically, the linear range may be expressed as the ratio of the upper limit of linearity obtained from the linearity plot and the minimum detectability, both measured for the same substance.

When presenting the linear range of a detector, either as a plot or as a numerical value, the test substance, the minimum detectability, and the specified deviation shall be stated.



Key

- A linear range
- B minimum detectability
- C upper limit of linearity
- D dynamic range

- E upper limit of dynamic range
- F 5% window
- X concentration or mass flow
- Y detector signal (peak area)

Figure B.2 — Alternative linear range representation

Annex C (informative)

Calculation test data

This Annex may be used to verify the calculation procedures for determining the carbon content and calorific value of a gas mixture. Two sets of compositions (S1 & S2) are given in Table C.1 with their corresponding results when performing the calculations according to Clause 7 and using the component data from Table D.1.

By entering the compositional data for S1 or S2 into the actual calculation program in use, the calculation procedure can be verified by comparing these results to the values given in Table C.1.

Table C.1 — Test data for verifying carbon content and calorific value calculations

	Composition		Carbon Content		Calorific Value	
	mol/100 mol	mol/100 mol	g C/100 g	g C/100 g	kJ/100 g	kJ/100 g
Component	S1	S2	S1	S2	S1	S2
Hydrogen	50,00	10,00	0,00	0,00	650,20	73,04
Argon	2,50	1,00	0,00	0,00	0,00	0,00
Nitrogen	10,00	43,00	0,00	0,00	0,00	0,00
Carbon monoxide	3,00	1,00	1,94	0,36	45,66	8,55
Carbon dioxide	1,00	3,00	0,65	1,09	0,00	0,00
Methane	10,00	5,00	6,46	1,81	431,79	121,26
Ethane	3,00	4,00	3,88	2,90	230,61	172,70
Ethylene	2,00	2,00	2,58	1,45	142,38	79,97
Acetylene	0,50	1,00	0,65	0,73	33,81	37,98
Propane	4,00	6,00	7,75	6,53	439,72	370,46
Propylene	2,00	3,00	3,88	3,27	207,23	174,59
Propyne	1,00	0,00	1,94	0,00	99,79	0,00
Propadiene	0,50	1,00	0,97	1,09	49,90	56,05
<i>iso</i> -butane	3,50	5,00	9,05	7,26	498,71	400,15
<i>n</i> -Butane	1,00	3,00	2,58	4,36	142,96	240,88
<i>trans</i> -2-Butene	0,00	3,00	0,00	4,36	0,00	229,38
1-Butene	1,00	2,00	2,58	2,90	136,70	153,56
<i>iso</i> -Butylene	1,00	1,00	2,58	1,45	135,80	76,27
<i>cis</i> -2-Butene	0,00	1,00	0,00	1,45	0,00	76,58
1,3-Butadiene	3,00	3,00	7,75	4,36	388,74	218,34
<i>iso</i> -pentane	0,60	0,75	1,94	1,36	105,38	73,98
<i>n</i> -Pentane	0,30	0,75	0,97	1,36	52,81	74,15
G6+ backflush	0,10	0,50	0,39	1,09	20,91	58,73
Total:	100,00	100,00	58,54	49,18	3813,11	2696,61

Annex D (normative)

Data for calculation

The carbon content, molar heating value and calorific value at 15° C that shall be used for the calculations are given in Table D.1.

Table D.1 —Component data for carbon content and calorific value

No	Component	Formula	Molar mass M_i (g/mol)	Carbon content W_{C_i} (gC/g)	Molar heating value H_{u_i} (kJ/mol)	Calorific value (mass based) H_{u_c} (kJ/g)
1	Hydrogen	H ₂	2,015 9	0	241,72	119,91
2	Helium	He	4,002 6	0	0	0
3	Oxygen	O ₂	31,998 8	0	0	0
4	Argon	Ar	39,948	0	0	0
5	Nitrogen	N ₂	28,013 5	0	0	0
6	Carbon monoxide	CO	28,010	0,428 8	282,91	10,10
7	Carbon dioxide	CO ₂	44,010	0,272 9	0	0
8	Hydrogen sulfide	H ₂ S	34,082	0	517,95	15,20
9	Carbon	C	12,011	1,000 0		
10	Methane	CH ₄	16,043	0,748 7	802,69	50,03
11	Ethane	C ₂ H ₆	30,070	0,798 9	1 428,84	47,52
12	Ethene	C ₂ H ₄	28,054	0,856 3	1 323,24	47,17
13	Ethyne (Acetylene)	C ₂ H ₂	26,038	0,922 6	1 256,94	48,27
14	Propane	C ₃ H ₈	44,097	0,817 1	2 043,37	46,34
15	Propene	C ₃ H ₆	42,081	0,856 3	1 926,13	45,77
16	Propyne (Methylacetylene)	C ₃ H ₄	40,065	0,899 4	1 855,09	46,30
17	Propadiene	C ₃ H ₄	40,065	0,899 4	1 855,09	46,30
18	<i>iso</i> -Butane	C ₄ H ₁₀	58,123	0,826 6	2 648,42	45,57
19	<i>n</i> -Butane	C ₄ H ₁₀	58,123	0,826 6	2 657,60	45,72
20	<i>trans</i> -2-Butene	C ₄ H ₈	56,108	0,856 3	2 530,50	45,10
21	1-Butene	C ₄ H ₈	56,108	0,856 3	2 540,97	45,29
22	2-Methyl-Propene	C ₄ H ₈	56,108	0,856 3	2 524,30	44,99
23	<i>cis</i> -2-Butene	C ₄ H ₈	56,108	0,856 3	2 534,20	45,17
24	1,3-Butadiene	C ₄ H ₆	54,092	0,888 2	2 408,80	44,53
25	<i>iso</i> -Pentane	C ₅ H ₁₂	72,150	0,832 4	3 265,08	45,25
26	<i>n</i> -Pentane	C ₅ H ₁₂	72,150	0,832 4	3 272,00	45,35
27	Other components with 5 or more carbon atoms	(C ₆ H ₁₄)	86,177	0,836 3	3 887,21	45,11

Bibliography

- [1] EN ISO 4259, *Petroleum products* *Determination and application of precision data in relation to methods of test (ISO 4259:2006)*
- [2] DIN 51405, *Testing of mineral oil hydrocarbons, similar liquids and solvents for paints and varnishes*
Analysis by gas chromatography *General working principles*
- [3] DIN 51666, *Testing of petroleum products* *Determination of composition for calculation of carbon content and calorific value of heating gas from refineries* *Gas chromatography method*

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards-based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With British Standards Online (BSOL) you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a BSI Subscribing Member.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a Multi-User Network Licence (MUNL) you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

All the data, software and documentation set out in all British Standards and other BSI publications are the property of and copyrighted by BSI, or some person

or entity that owns copyright in the information used (such as the international standardization bodies) and has formally licensed such information to BSI for commercial publication and use. Except as permitted under the Copyright, Designs

and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI. Details and advice can be obtained from the Copyright & Licensing Department.

Useful Contacts:

Customer Services

Tel: +44 845 086 9001

Email (orders): orders@bsigroup.com

Email (enquiries): cservices@bsigroup.com

Subscriptions

Tel: +44 845 086 9001

Email: subscriptions@bsigroup.com

Knowledge Centre

Tel: +44 20 8996 7004

Email: knowledgecentre@bsigroup.com

Copyright & Licensing

Tel: +44 20 8996 7070

Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK



...making excellence a habit.™