



Technical Report

ISO/TR 17910

Natural gas — Coal-based synthetic natural gas quality designation and the applicability of ISO/TC 193 standards

*Gaz naturel — Désignation de la qualité du gaz naturel
synthétique à base de charbon et applicabilité des normes de
l'ISO/TC 193*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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This document was prepared by Technical Committee ISO/TC 193, *Natural gas*, Subcommittee SC 1, *Analysis of natural gas*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Coal-based synthetic natural gas (CBSNG) is a natural gas substitute. It refers to a natural gas-like mixture that is synthesized from coal. After gasification or coking, the coal releases gas that mainly contains CO, CO₂ and H₂. Then after the gas cleaning, the water gas shift and methanation process consecutively, the final product is coal based synthetic natural gas.

During the production process, the sulphur, CO₂, particle and NO_x emission can be controlled to a very low level compared to the direct utilization of coal. So the CBSNG can be considered as a clean energy resource.

At present, the production of CBSNG is mainly in the United States and China. There are plans of CBSNG projects also in South Korea, Ukraine, and Brazil.

Typical CBSNG contains more than 90 % methane and up to 5 % hydrogen, as well as a small portion of nitrogen and carbon dioxide, minor ethane, propane and traces of ammonia. This document aims to promote communication and coordination among countries, and to support the smooth progress of natural gas substitute development, production and custody transfer.

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Natural gas — Coal-based synthetic natural gas quality designation and the applicability of ISO/TC 193 standards

1 Scope

This document introduces the production process, the distribution and quality designation of coal-based synthetic natural gas (CBSNG) in many places around the world, and examines whether ISO/TC 193 standards for sampling, test and calculation methods are applicable to the CBSNG product.

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.

ISO 14532, *Natural gas — Vocabulary*

3 Terms and definitions

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

ISO and IEC maintain terminological 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

natural gas

NG

complex gaseous mixture of hydrocarbons, primarily methane, but generally includes ethane, propane and higher hydrocarbons, and some non-combustible gases such as nitrogen and carbon dioxide

Note 1 to entry: Natural gas can also contain components or containments such as sulfur compounds and/or other chemical species.

[SOURCE: ISO 14532:2014, 2.1.1.1]

3.2

indirect sampling

sampling in situations where there is no direct connection between the natural gas to be sampled and the analytical unit

[SOURCE: ISO 14532:2014, 2.3.1.2]

3.3

representative sample

sample having the same composition as the natural gas sample when the latter is considered as a homogeneous whole

[SOURCE: ISO 14532:2014, 2.3.4.2]

3.4
electrochemical detector
ED

detector consisting of an electrochemical cell that responds to certain substances contained in the carrier gas eluting from the column

Note 1 to entry: The electrochemical process can be an oxidation, reduction, or a change in conductivity. The detection can be very specific depending on the electrochemical process involved.

[SOURCE: ISO 14532:2014, 2.4.7]

3.5
main component
major component

component whose content influences physical properties

[SOURCE: ISO 14532:2014, 2.5.2.2.1]

3.6
minor component

component whose content does not significantly influence the calculation of physical properties

[SOURCE: ISO 14532:2014, 2.5.2.2.2]

3.7
trace constituent

component present at very low levels

[SOURCE: ISO 14532:2014, 2.5.2.2.3]

3.8
total sulfur

total amount of sulfur found in coal bed methane

[SOURCE: ISO 14532:2014, 2.5.2.3.14]

3.9
compression factor

ratio of the volume of an arbitrary mass of gas at a specified pressure and temperature to the volume of the same mass of gas under the same conditions as calculated from the ideal-gas law

[SOURCE: ISO 14532:2014, 2.6.2.2]

3.10
density

mass of gas divided by its volume at specified conditions of pressure and temperature

[SOURCE: ISO 14532:2014, 2.6.3.1]

3.11
relative density

ratio of the mass of a gas contained within an arbitrary volume to the mass of dry air of standard composition that would be contained in the same volume at the same reference conditions

[SOURCE: ISO 14532:2014, 2.6.3.2]

Note 1 to entry: The dry air of standard composition is defined in ISO 6976.

3.12

Wobbe index

calorific value on a volumetric basis at specified reference conditions, divided by the square root of the relative density at the same specified metering reference conditions

[SOURCE: ISO 14532:2014, 2.6.4.3]

3.13

water dew point

temperature at a specified pressure at which water vapour condensation initiates

Note 1 to entry: For any pressure lower than the specified pressure, there is no condensation of water vapours at this water dew point temperature.

[SOURCE: ISO 14532:2014, 2.6.5.1.1]

3.14

water content

mass concentration of the total amount of water contained in a gas

Note 1 to entry: Water content is expressed in units of mass per unit volume.

Note 2 to entry: For gas below the water dew point, this means water in the form of both liquid and vapour; but for gas above the water dew point, this means only water vapour.

Note 3 to entry: Water content can be also expressed as mole or volume fraction.

[SOURCE: ISO 14532:2014, 2.6.5.1.2]

3.15

hydrocarbon dew point

HCDP

temperature at a specified pressure at which hydrocarbon vapour condensation initiates

Note 1 to entry: In chemical thermodynamics, the "true" hydrocarbon dew point is the temperature (at a stated pressure) at which the fugacity of the gas and liquid phases is identical. Since measurement of the dew point involves reduction of the system temperature, this equates to the temperature at which the first appearance of the liquid phase occurs. At this point, the quantity of liquid phase is infinitesimally small. Since no instrument or observer is able to detect this infinitesimally small amount, the measured value by a chilled mirror instrument (measured hydrocarbon dew point) differs from the "true" hydrocarbon dew point. Depending on the gas composition and the sensitivity of the detection system of the automatic hydrocarbon-dew-point chilled-mirror instrument or the observer (manual chilled mirror instrument), the measured hydrocarbon dew point can be considerably lower than the "true" hydrocarbon dew point.

[SOURCE: ISO 14532:2014, 2.6.5.2.1]

3.16

potential hydrocarbon liquid content

PHLC

property of natural gas defined as the amount of the condensable liquid (in milligrams) at the pressure, p , and temperature, T , per unit volume of gas at normal conditions, that is, at a temperature of 0 °C and a pressure of 101,325 kPa obtained by passing a representative sample of the gas through an apparatus where it is first brought to the pressure, p , and then cooled to the temperature, T

Note 1 to entry: It is necessary to take care that only gas, not a two-phase mixture, has been withdrawn from the pipeline.

[SOURCE: ISO 14532:2014, 2.6.5.2.3]

3.17

interchangeability

measure of the degree to which the combustion characteristics of one gas resemble those of another gas

Note 1 to entry: Two gases are said to be interchangeable when one gas may be substituted for the other without affecting the operation of gas burning appliances or equipment.

[SOURCE: ISO 14532:2014, 2.7.1]

3.18

coal based synthetic natural gas

CBSNG

gaseous mixture synthesized from coal, primarily methane and hydrogen, but generally includes ethane and some non-combustible gases such as nitrogen and carbon dioxide

4 Symbols and units

Symbol	Meaning and units
D	Density (kg/m ³)
G	Relative density
H_c	Molar basis calorific value (kJ/mol)
H_m	Mass basis calorific value (MJ/kg)
H_v	Volumetric basis calorific value (MJ/m ³)
M	molar mass (kg/kmol)
p	(Absolute) pressure (kPa)
t	Celsius temperature (°C)
T	Thermodynamic (absolute) temperature (K)
V	(Gas) volume (m ³)
W	Wobbe index (MJ/m ³)
Z	Compression factor

5 Brief introduction to CBSNG

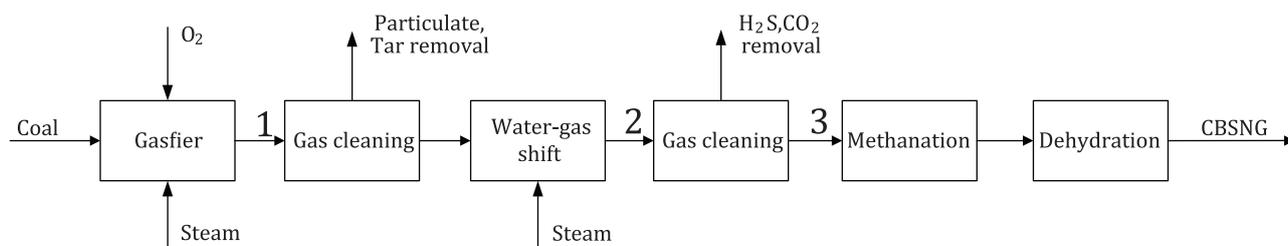
5.1 The production progress of CBSNG

CBSNG is a natural gas (NG) substitute, the main component of which is methane. Through gasification, the water gas shift, gas cleaning and methanation, CBSNG can be produced from coal and water.

The production process of CBSNG is shown in [Figure 1](#) and as follows: after the raw coal is broken and screened, it enters the coal gasification unit to produce raw syngas. The vaporizing agent in the gasifier is the medium pressure steam and oxygen produced by the air separation unit. After passing through the gas cleaning unit to remove particulate and tar, the raw syngas then enters into the water-gas shift unit to shift the gas to meet the H₂/CO ratio requirement of the methanation process, and a stream of steam is used to recover the reaction energy of water-gas shift process.

The shift syngas exiting the water-gas shift unit goes into the gas cleaning unit to remove most of the acid gas. The clean shift gas from the gas cleaning unit is mainly CO and H₂, which enters into the methanation unit to produce synthetic natural gas. After the dehydration and compression, the final gas is the CBSNG product.

The typical mole fraction of intermediate gases in the CBSNG production process is listed in [Table 2](#).



Key

- 1 raw syngas
- 2 shift syngas
- 3 clean shift syngas

NOTE 1,2,3 represent intermediate gases in [Table 1](#).

Figure 1 — The CBSNG production process diagram

Typical methanation process has four reactors. The CH₄ mole fraction in cleaning syngas gradually increases to more than 90 percent when the gas is moving forward in these methanation reactors.

Table 1 — Typical mole fraction of intermediate gases and CBSNG in the CBSNG production process

Component	Mole fraction %			
	1	2	3	CBSNG
O ₂	0,20	0,06	0,09	0,012
N ₂	0,06	0,04	0,06	0,13
CH ₄	12,51	11,54	18,05	98,37
CO ₂	34,60	36,10	1,06	0,60
CO	14,70	12,98	20,34	—
C ₂ H ₆	0,43	0,07	0,11	—
C ₃ H ₈	0,10	0,01	0,01	—
H ₂	37,50	39,20	61,30	0,88

5.2 The distribution of CBSNG

There are five CBSNG projects in production globally which have a production of 6,867 billion cubic meters per year. These projects are mainly distributed in Neimenggu and Xinjiang in China and North Dakota in the U.S.A. More detailed information of these five projects is as follows.

There are four production lines that have been put into use in China. The designed production is about two billion cubic meters a year per project, and are being put to use step-by-step. Until 2020, the total production that has been put to use is 5,12 billion cubic meters per year in China.

There is a CBSNG project in the USA which has been working since 1984 and has a production of 1,76 billion cubic meters a year.

All the CBSNG product from the five projects in production enter pipelines to mix with natural gas to be transported and consumed.

Table 2 — Information of five projects in production globally

Location	Production since	Designed production	Real production
Neimenggu, China	2013	4,0 billion m ³ /y	1,335 billion m ³ /y (first step)
Xinjiang, China	2013	5,5 billion m ³ /y	1,375 billion m ³ /y (first step)
Neimenggu, China	2014	2,0 billion m ³ /y	0,4 billion m ³ /y (first step)
Xinjiang, China	2017	2,0 billion m ³ /y	2,0 billion m ³ /y
North Dakota, United States	1984	7,0 million m ³ /d	1,757 billion m ³ /y

There are also four projects under construction with a total capacity about 6,5 billion cubic meters per year. There are 18 planned CBSNG projects with a total capacity about 72,3 billion cubic meters per year. Except one project under construction from South Korea and one project in the planning from Mongolia, the projects under construction and in planning are mainly in China.

5.3 Components and composition range of typical CBSNG

The CBSNG composition from the five projects in production has been studied. The results are shown in [Table 3](#).

Table 3 — Components and range of composition of CBSNG product of 5 projects in operation

Location	Components and range of composition						
	mol%						
	CH ₄	H ₂	CO ₂	N ₂	CO	O ₂	C ₂ H ₆
Qinghua, Xinjiang, China	98,10	1,16	0,64	0,10	—	—	0,012 9
Datang, Neimenggu, China	97,86	0,83	0,7	0,18	—	—	—
Xingtian, Xinjiang, China	<94	<2,2	<2	<2	<0,01	<0,2	—
Huineng, Neimenggu, China	95,4~98,6	0,26~2,07	0,036~0,319	—	0,001~0,143	—	—
The Great Plains, North Dakota, United States	94,8~96,1	2,4~3,98	0,41~1,26	0,03~0,35	0~0,03	—	—

The three conclusions that can be drawn on the gas quality of CBSNG from [Table 3](#) are:

- 1) There will be more than 90 % CH₄ and small percentage of H₂ in CBSNG. The content of CO₂ in CBSNG is similar to that in natural gas.
- 2) The CO in CBSNG is at trace level.
- 3) There is no hydrocarbon higher than ethane in CBSNG.

6 Applicability of sampling standard

ISO 10715 provides concise guidelines for the collection, conditioning and handling of representative samples of processed natural gas streams. It also contains guidelines for sampling strategy, probing the location and the handling and designing of the sampling equipment. According to ISO 10715, the factors affecting sampling representativeness include: sampling material and equipment, sample containers, sampling method, heavy hydrocarbon condensate and flow characteristics of gas sources.

For the final product, CBSNG is a kind of synthetic natural gas, which falls into the category of a natural gas substitute in the scope of ISO/TC 193. It is basically free of heavy hydrocarbon and organic sulfur compounds. The composition of CBSNG is simpler than that of natural gas.

Therefore, ISO 10715 is applicable to the direct and indirect sampling of CBSNG.

7 Applicability of test and calculation standard

7.1 General

This clause deals with the various parameters which may be referred to in the designation of the quality of CBSNG according to ISO 13686. The parameters actually selected will depend upon the purpose for which the designation is required and it is unlikely that all the parameters listed in this technical report will be used.

7.2 Gas composition

7.2.1 General

CBSNG is composed primarily of methane and hydrogen with smaller amounts of ethane and of the noncombustible gases carbon dioxide and nitrogen - the approximate content of each component is shown in [Table 4](#). The relevant ISO/TC 193 test standards for major and minor components and trace constituents, and whether these standards are applicable to CBSNG, are shown in [Tables 5, 10 and 14](#).

This document does not give requirements of CBSNG. For requirements, one can refer to Chinese national standard GB/T 33445^[34] (see [Annex A](#)).

Table 4 — Approximate content of each component of CBSNG

Component	Unit	Approximate content range
Methane	cmol/mol	>90,0
Hydrogen	cmol/mol	0 to 5,0
Nitrogen	cmol/mol	0 to 3,0
Carbon dioxide	cmol/mol	0,1 to 2,0
Ethane	cmol/mol	0 to 0,2
Propane	cmol/mol	0 to 0,1
Oxygen	cmol/mol	0 to 0,2
Carbon monoxide	cmol/mol	0 to 0,1
Argon	cmol/mol	0 to 0,1
Ammonia	mg/m ³	0 to 50,0
Sulfur hydrogen	mg/m ³	0 to 20,0
Total sulfur	mg/m ³	0 to 50,0

7.2.2 Major components

Table 5 — Major components of CBSNG

Component	Relevant ISO/TC 193 standards	Whether applicable to CBSNG
Methane	ISO 6974-1 to ISO 6974-6, ISO 23978	Yes
Hydrogen	ISO 6974-3, ISO 6974-6, ISO 6975	Not exactly
Nitrogen	ISO 6974-1 to ISO 6974-6, ISO 23978	Yes
Carbon dioxide	ISO 6974-1 to ISO 6974-6, ISO 6975, ISO 23978	Yes

7.2.2.1 Methane

ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are suitable for the determination of methane in the range of 75 % to 100 %, 34 % to 100 %, 40 % to 100 %, and 50 % to 100 %, respectively, see [Table 6](#).

Generally, the methane content in CBSNG is basically above 90 %.

Therefore, ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are applicable to the determination of methane content in CBSNG. ISO 6974-1, ISO 6974-2, and ISO 6974-3 are also applicable in the determination of methane content in CBSNG.

Table 6 — Summary of determination range of CH₄ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
>90 %	ISO 6974-4	75 % to 100 %	Yes
	ISO 6974-5	34 % to 100 %	Yes
	ISO 6974-6	40 % to 100 %	Yes
	ISO 23978	50 % to 100 %	Yes

7.2.2.2 Hydrogen

The scopes of ISO 6974-4 and ISO 6974-5 do not include the determination of hydrogen. ISO 6974-3, ISO 6974-6 and ISO 6975 are suitable for the determination of hydrogen in the range of 0,001 % to 0,5 %, see [Table 7](#).

Generally, the hydrogen content in CBSNG is 0,1 % to 5,0 %.

Therefore, when the hydrogen content in CBSNG exceeds 0,5 %, ISO 6974-3, ISO 6974-6 and ISO 6975 are not applicable to the determination of hydrogen content in CBSNG.

Three relevant standard hydrogen test methods from other countries or organizations can be referred to [Annex B](#). Two of these standards are applicable for the determination of hydrogen in the range of 0,01 % to 10,0 % and one standard is applicable for the determination of hydrogen in the range of 0,03 % to 100 %.

Table 7 — Summary of determination range of H₂ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 5 %	ISO 6974-3	0,001 % to 0,5 %	Not exactly
	ISO 6974-6	0,001 % to 0,5 %	Not exactly
	ISO 6975	0,001 % to 0,5 %	Not exactly

7.2.2.3 Nitrogen

ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are suitable for the determination of nitrogen in the ranges of 0,001 % to 15 %, 0,1 % to 22 %, 0,007 % to 40 %, and 0,02 % to 10 %, respectively, see [Table 8](#).

Nitrogen content in CBSNG is commonly below 2 %. Therefore, ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are basically applicable to the determination of nitrogen content in CBSNG.

Table 8 — Summary of determination range of N₂ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 2 %	ISO 6974-4	0,001 % to 15 %	Yes
	ISO 6974-5	0,1 % to 22 %	Yes
	ISO 6974-6	0,007 % to 40 %	Yes
	ISO 23978	0,02 % to 10 %	Yes

7.2.2.4 Carbon dioxide

ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are suitable for the determination of carbon dioxide in the range of 0,001 % to 10 %, 0,05 % to 15 %, 0,001 % to 10 % and 0,02 % to 3,0 %, respectively, see [Table 9](#).

Carbon dioxide content in CBSNG is commonly below 3,0 %.

Therefore, ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are applicable to the determination of carbon dioxide content in CBSNG.

Table 9 — Summary of determination range of CO₂ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 3 %	ISO 6974-4	0,001 % to 10 %	Yes
	ISO 6974-5	0,05 % to 15 %	Yes
	ISO 6974-6	0,001 % to 10 %	Yes
	ISO 23978	0,02 % to 30 %	Yes

7.2.3 Minor components

Table 10 — Minor components of CBSNG

Component	Relevant ISO/TC 193 standards	Whether applicable to CBSNG
Ethane	ISO 6974-1 to ISO 6974-6	Yes
Propane	ISO 6974-1 to ISO 6974-6	Yes
Oxygen	ISO 6974-6, ISO 6975	Yes
Carbon monoxide	ISO 6974-6	Yes
Argon	ISO 6975	Yes

7.2.3.1 Ethane

ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are suitable for the determination of ethane in the range of 0,001 % to 10 %, 0,1 % to 23 %, 0,002 % to 15 %, and 0,02 % to 20 %, respectively, see [Table 11](#).

Generally, the ethane content in CBSNG is basically lower than 0,2 %.

Therefore, ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are applicable to the determination of ethane content in CBSNG.

Table 11 — Summary of determination range of C₂H₆ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 0,2 %	ISO 6974-4	0,001 % to 10 %	Yes
	ISO 6974-5	0,1 % to 23 %	Yes
	ISO 6974-6	0,002 % to 15 %	Yes
	ISO 23978	0,02 % to 20 %	Yes

7.2.3.2 Propane

ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are suitable for the determination of propane in the range of 0,001 % to 3 %, 0,05 % to 10 %, 0,001 % to 5 % and 0,02 % to 10 %, respectively, see [Table 12](#).

Generally, the propane content in CBSNG is basically lower than 0,1 %.

Therefore, ISO 6974-4, ISO 6974-5, ISO 6974-6 and ISO 23978 are applicable to the determination of propane content in CBSNG.

Table 12 — Summary of determination range of C₃H₈ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 0,1 %	ISO 6974-4	0,001 % to 3 %	Yes
	ISO 6974-5	0,05 % to 10 %	Yes
	ISO 6974-6	0,001 % to 5 %	Yes
	ISO 23978	0,02 % to 10 %	Yes

7.2.3.3 Oxygen

The scopes of ISO 6974-4 and ISO 6974-5 do not include the determination of oxygen. ISO 6974-6 and ISO 6975 are suitable for the determination of oxygen in the range of 0,007 % to 5 %, and 0,001 % to 0,5 %, respectively, see [Table 13](#).

Generally, the oxygen content in CBSNG is not higher than 0,2 %.

Therefore, ISO 6974-6 and ISO 6975 are applicable to the determination of oxygen content in CBSNG.

Table 13 — Summary of determination range of O₂ by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 % to 0,2 %	ISO 6974-6	0,007 % to 5 %	Yes
	ISO 6975	0,001 % to 0,5 %	Yes

7.2.3.4 Carbon monoxide

The scopes of ISO 6974-4 and ISO 6974-5 do not include the determination of carbon monoxide. ISO 6974-6 is suitable for the determination of carbon monoxide in the range of 0,001 % to 1 %.

A small amount of CBSNG contains carbon monoxide which is less than 0,1 %.

Therefore, ISO 6974-6 is applicable to the determination of carbon monoxide content in CBSNG.

7.2.3.5 Argon

The scopes of ISO 6974-4 and ISO 6974-5 do not include the determination of argon. ISO 6975 is suitable for the determination of argon in the range of 0,001 % to 0,5 %.

Generally, the argon content in CBSNG is less than 0,1 %.

Therefore, ISO 6975 is applicable to the determination of argon content in CBSNG.

7.2.4 Trace constituents

Table 14 — Trace constituents of CBSNG

Component	Relevant ISO/TC 193 standards	Whether applicable to CBSNG
Hydrogen sulfide	ISO 19739, ISO 23978	Yes
Total sulfur	ISO 16960, ISO 20729	Yes
Ammonia	None	No

7.2.4.1 Hydrogen sulfide

There are several methods for the determination of sulfur compounds described in the annexes of ISO 19739:2004, of which Annex C and Annex H are both suitable for the determination of hydrogen sulfide in the range of 0,5 mg/m³ to 600 mg/m³. Annex D and Annex E are both suitable for the determination of hydrogen sulfide in the range of 0,1 mg/m³ to 100 mg/m³. Annex F, Annex G and Annex I are all applicable to the determination of hydrogen sulfide, but do not specify the detection ranges.

ISO 23978 is suitable for the determination of hydrogen sulfide in the range of 0,02 % to 10 %, see [Table 15](#).

Generally, the hydrogen sulfide content in CBSNG is less than 6 mg/m³, and about 20 mg/m³ when it is higher.

Therefore, ISO 19739 is applicable to the determination of hydrogen sulfide in CBSNG.

Table 15 — Summary of determination range of H₂S by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Method	Suitable determination range	Whether applicable to CBSNG
0 mg/m ³ to 20 mg/m ³	ISO 19739	GC-FPD	0,5 mg/m ³ to 600 mg/m ³	Yes
	ISO 19739	GC-SCD	0,5 mg/m ³ to 600 mg/m ³	Yes
	ISO 19739	GC-ED	0,1 mg/m ³ to 100 mg/m ³	Yes
	ISO 19739	GC-MSD	0,1 mg/m ³ to 100 mg/m ³	Yes
	ISO 23978	Laser Raman spectroscopy	0,02 % to 10 %	No

7.2.4.2 Total sulfur

ISO 16960 and ISO 20729 are suitable for the determination of total sulfur content in CBSNG in the range of 1 mg/m³ to 200 mg/m³ and 1 mg/m³ to 150 mg/m³, respectively, see [Table 16](#).

Generally, the total sulfur content in CBSNG is less than 6 mg/m³, and about 50 mg/m³ when it is higher.

Therefore, ISO 16960 and ISO 20729 are both applicable to the determination of total sulfur in CBSNG.

Table 16 — Summary of determination range of total sulfur by relevant ISO/TC 193 standards

Content in CBSNG	Relevant ISO/TC 193 standards	Suitable determination range	Whether applicable to CBSNG
0 mg/m ³ to 50 mg/m ³	ISO 16960	1 mg/m ³ to 200 mg/m ³	Yes
	ISO 20729	1 mg/m ³ to 150 mg/m ³	Yes

7.2.4.3 Ammonia

There are no relevant standard methods for determination of ammonia content in ISO/TC 193 standards.

Traces of ammonia can be found in the CBSNG product. Generally, the content of ammonia in CBSNG is less than 50 mg/m³.

Some relevant standard test methods for ammonia can be referred to [Annex C](#)^{[31][37][38][39]}. The analysis of ammonia by Fourier transform infrared (FTIR) spectroscopy and optical feedback cavity enhanced absorption spectroscopy (OF-CEAS) are also reported in some research works^[39]. ISO 2612¹⁾ describes suitable calibration and measurement strategies to quantify ammonia in (bio)methane up to 10 mg m⁻³

7.3 Gas properties

7.3.1 General

Physical properties and whether the relevant ISO/TC 193 standards are applicable to CBSNG are shown in [Table 17](#). For interchangeability, CBSNG is taken as an example to evaluate the applicability of four different methods in ISO 13686. [Annex D](#) gives the detailed information.

7.3.2 Physical properties

Table 17 — Physical properties of CBSNG

Properties	Unit	Relevant ISO/TC 193 standards	Whether applicable to CBSNG
Molar basis calorific value, H_c	MJ/mol	ISO 6976, ISO 15971	Yes
Mass basis calorific value, H_m	MJ/kg	ISO 6976, ISO 15971	Yes
Volumetric basis calorific value, H_v	MJ/m ³	ISO 6976, ISO 15971	Yes
Relative density, d	-	ISO 6976, ISO 15970	Yes
Wobbe index, w	MJ/m ³	ISO 6976, ISO 15971	Yes
Water dew point	°C[K]	ISO 6327, ISO 18453	Yes
Water content	mg/m ³	ISO 10101-1, ISO 18453 ISO 10101-2, ISO 10101-3 ISO 11541	Yes
Hydrocarbon dew point (HCDP)	°C[K]	ISO 23874	Yes
Liquid hydrocarbon content	mg/m ³	ISO 6570	Yes

7.3.2.1 Calorific value, relative density and Wobbe index

ISO 6976 specifies methods for the calculation of gross calorific value, net calorific value, density, relative density, gross Wobbe index and net Wobbe index of natural gases, natural gas substitutes and other

1) Under preparation. Stage at the time of publication: ISO/FDIS 2612:2023.

combustible gaseous fuels when the composition of the gas by mole fraction is known. The methods specified provide the means of calculating the properties of the gas mixture at commonly used reference conditions.

Mole fractions by definition sum up to unity. Guidance on the achievement of this requirement by a chromatographic analysis is available in ISO 6974-1 and ISO 6974-2.

The methods of calculation require values for various physical properties of the pure components; these values, together with associated uncertainties, are provided in tables and their sources are identified.

Methods are given for estimating the standard uncertainties of calculated properties.

The methods of calculation of the values of properties on either a molar, mass or volume basis are applicable to any natural gas, natural gas substitute or other combustible fuel that is normally gaseous, except that for properties on the volume basis the method is restricted to mixtures for which the compression factor at reference conditions is greater than 0,9.

ISO 6976 is applicable to the calculation of calorific value, relative density and Wobbe index of CBSNG.

In addition, ISO 15970 is applicable to the measurement of relative density of CBSNG, and ISO 15971 is applicable to the measurement of calorific value and the Wobbe index of CBSNG.

7.3.2.2 Water dew point and water content

ISO 6327 describes a method for determination of water dew point of natural gas by cooled surface condensation hygrometers, which is applicable to the determination of water dew point of natural gas and similar gases. The water dew point of processed natural gases in transmission lines normally lies between -25 °C and +5 °C, which corresponds to water volume fraction of 50 cm³/m³ to 200 cm³/m³, depending on gas pressure.

ISO 6327, ISO 18453, ISO 10101 (all parts), and ISO 11541 are all able to be applied for the determination and conversion of water dew point and water content.

The Chinese experts detecting water dew point in recent years found that the results of water dew point determination of natural gas treated by triethylene glycol dehydration process are not accurate, especially by the chilled mirror method which is often disturbed by triethylene glycol droplets, causing a large deviation in measurement results.

7.3.2.3 Hydrocarbon dew point and hydrocarbon liquid content

ISO 23874 describes the performance requirements for analysis of treated natural gas of transmission or pipeline quality in sufficient detail so that the hydrocarbon dewpoint temperature can be calculated using an appropriate equation of state. It can be applied to gases that have maximum dewpoint temperatures (cricondentherms) between 0 °C and -50 °C. The pressures at which these maximum dewpoint temperatures are calculated are in the range 2 MPa (20 bar) to 5 MPa (50 bar). Major components are measured using ISO 6974 (all parts) and the ranges of components that can be measured are as defined in ISO 6974-1.

The procedure given in ISO 23874 covers the measurement of hydrocarbons in the range C5 to C12. n-Pentane, which is quantitatively measured using ISO 6974 (all parts), is used as a bridge component and all C6 and higher hydrocarbons are measured relative to n-pentane.

CBSNG basically does not contain C6 and C6⁺. Therefore, ISO 23874 is applicable to CBSNG.

ISO 6570 describes the principles of, and general requirements for, two gravimetric methods for the determination of the potential hydrocarbon liquid content (PHLC) of natural gas, or similar gas, at a given pressure and temperature. Two methods are specified in ISO 6570 to determine the amount of condensate in a sample gas:

- Method A: a manual weighing method;
- Method B: an indirect automatic weighing method based on the indication of the pressure difference caused by the accumulation of condensate in a vertical tube.

The manual weighing method is a reference method for the indirect automatic method. The indirect automatic method is suitable for semi-continuous control.

ISO 6570 is applicable to CBSNG.

ISO/TR 11150 describes three means of estimating hydrocarbon dew point and hydrocarbon content of natural gas and they are:

- a) the cooled mirror method which determines hydrocarbon dew point and hydrocarbon content, including visual method and automatic measurement method;
- b) the gas chromatography method, by which the composition of gas is analyzed and used to calculate the hydrocarbon dew point; and,
- 3) the gravimetric method is used to determine the potential hydrocarbon liquid content.

At present, commercial instruments for hydrocarbon dew point determination of natural gas by visual or automatic measurement methods have been widely used. The Chinese national standard GB/T 27895^[33] uses cooled mirror method to determine the hydrocarbon dew point of natural gas. There is no corresponding ISO standard. It is recommended to develop an ISO standard for the determination of hydrocarbon dew point.

ISO/TR 11150 is applicable to CBSNG.

7.4 Solid particulate matter

The solid particulate matter in CBSNG has an impact on the safe transportation, utilization and accuracy of gas metering. It is necessary to accurately determine the solid particulate matter in CBSNG and natural gas.

The solid particulate matter in CBSNG is limited to not more than 1 mg/m³ in Chinese national standard, GB/T 33445^[34], for coal-based synthetic natural gas.

China has developed the national standard GB/T 27893^[32], which specifies the method for determination of particle content in natural gas by membrane weighing method. The measurement pressure range is between 0,1 MPa and 6 MPa. The measurement range is 0,1 mg/m³ to 100 mg/m³. If the membrane trap and the entire sampling and trapping system can withstand higher pressures, the measurement pressure can also be increased to the corresponding pressure.

ISO/TC 193 has no corresponding standard method.

Annex A (informative)

Technical requirements and test methods for CBSNG

This annex gives the quality designations as well as the test methods on CBSNG components or properties according to the Chinese national standard GB/T 33445.

Table A.1 — Quality designations and test methods for CBSNG in Chinese national standard GB/T 33445

Items	Class I	Class II	Class III	Test or calculation methods
Superior calorific value ^a , MJ/m ³	≥35,0	≥31,4	≥31,4	ISO 6976 GB/T 11062
Hydrogen mole fraction, %	≤3,5	≤5,0	To be agreed between supplier and user	
Carbon dioxide mole fraction, %	≤2,0	≤3,0	To be agreed between supplier and user	
Hydrogen sulfide mass concentration ^a , mg/m ³		≤1,0		GB/T 11060.2 GB/T 18605.2 GB/T 11061
Carbon monoxide mole fraction, %		≤0,15		
Ammonia mole fraction, micromol/mol		≤50,0		
Particle mass concentration ^a , mg/m ³		≤1,0		GB/T 27893
Water dew point ^{b,c} , °C	Under the pressure of the custody transfer point, the water dew point is recommended to be 5 °C lower than the minimum ambient temperature under the transportation condition.			GB/T 17283
^a The reference conditions of gas volume in this standard is 101,325 kPa, 20 °C. ^b Under the transportation condition, when the ground temperature at the pipe top is 0 °C, the water dew point is recommended not to be higher than -5 °C. ^c The dew point temperature pressure is the maximum transmission pressure.				

Annex B
(informative)

Test methods for hydrogen

B.1 General

This annex gives a brief description of three test methods for hydrogen concentration, one is from a Chinese national standard and two are from ASTM.

B.2 Chinese national standard GB/T 13610

Chinese national standard GB/T 13610^[31] is suitable for the determination of hydrogen content in the range of 0,01 % to 10 % by gas chromatography.

B.3 ASTM D1945

ASTM D1945^[35] is suitable for the determination of hydrogen content in the range of 0,01 % to 10 % by gas chromatography.

B.4 ASTM D7833

ASTM D7833^[36] is suitable for the determination of hydrogen content in the range of 0,03 % to 100 % by gas chromatography.

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Annex C (informative)

Test methods for ammonia

C.1 General

This annex gives a brief description of three ammonia test methods, which are from a Chinese national standard, a Dutch standard and an ISO standard, respectively.

C.2 Chinese national standard GB/T 33445

It is recommended to use spectrophotometer to detect ammonia content in CBSNG according to the Chinese national standard GB/T 33445^[34]. The principle of this method is that in the presence of ascorbic acid and heating (95 °C), ammonia and ninhydrin react in a weak acidic acetic acid-sodium acetate buffer medium to form a blue-purple compound, the colorimetry was carried out at the wavelength of 568 nm with a spectrophotometer.

C.3 Dutch standard NEN 2826

BSI/EN 16723^[38] refers to NEN 2826^[34], which is suitable for ammonia content from 0,1 to 3 000 mg/m³, as the ammonia content determination method to detect ammonia content which is limited to 10 mg/m³ in biomethane.

C.4 ISO 2612

ISO 2612^[1] describes suitable calibration and measurement strategies to quantify ammonia in (bio)methane around the 10 mg/m³.

Annex D (informative)

Applicability of interchangeability

D.1 General

Interchangeability is defined as the ability of a distributed natural gas to be substituted by another without the need for adjustment at the customer's equipment. ISO 13686 gives four different methods to predict the interchangeability between two gases.

Hydrogen content in CBSNG is the main factor which will influence its interchangeability to conventional natural gas. One typical CBSNG that has the richest hydrogen content from the composition range of CBSNG from [Table D.1](#) was taken as an example to evaluate the interchangeability of CBSNG.

Table D.1 — Composition of typical CBSNG for interchangeability evaluation

Component	Mole fraction %
Methane	94,60
Hydrogen	3,98
Nitrogen	0,30
Carbon dioxide	0,90
Ethane	0,10
Oxygen	0,10
Carbon monoxide	0,02

D.2 AGA index method

Interchangeability in the AGA program is determined by calculating indexes for lifting, flashback, and yellow tipping (complete combustion). The limit values of the three indices and corresponding calculated indices values of the typical CBSNG are listed in [Table D.2](#).

Table D.2 — Three AGA interchangeability indices limits and calculated values of typical CBSNG

Index	Limit	Calculated value	Interchangeability
Lifting index	$\leq 1,126$	0,983	Yes
Flashback index	$\geq 1,021$	1,056	Yes
Yellow tip index	$\leq 1,177$	1,043	Yes

The calculated indices values of the typical CBSNG are all located in the interchangeable range. So the CBSNG is interchangeable according to AGA index method.

D.3 British gas hydrocarbon equivalence method

According to British gas hydrocarbon equivalence method, interchangeability can be visually displayed on a plot of Wobbe index and the sum of the mole fractions of propane and nitrogen in the equivalent mixture. This is shown in [Figure D.1](#). The typical CBSNG mixture lies within the area permitted for normal operation and is therefore interchangeable.