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

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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*.

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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, CO_2 and H_2. 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, CO_2, 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.

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 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

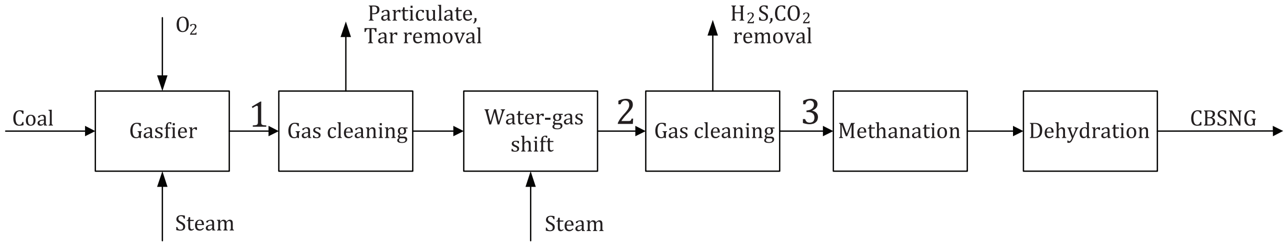
5.1 The production progress of CBSNG

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 H_2/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 H_2, 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 CH_4 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_2H_6	0,43	0,07	0,11	—
C_3H_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 Nei Menggu and Xin Jiang 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
Nei Menggu, China	2013	4,0 billion m^3/y	1,335 billion m^3/y (first step)
Xin Jiang, China	2013	5,5 billion m^3/y	1,375 billion m^3/y (first step)
Nei Menggu, China	2014	2,0 billion m^3/y	0,4 billion m^3/y (first step)
Xin Jiang, 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_2H_6
QingHua, Xin Jiang, China	98,10	1,16	0,64	0,10	—	—	0,012 9
DaTang, NeiMenggu, China	97,86	0,83	0,7	0,18	—	—	—
XingTian, Xin Jiang, 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 % CH_4 and small percentage of H_2 in CBSNG. The content of CO_2 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.

