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Specification for Iranian Natural Gas Quality



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باسلام،

به استحضار می‌رساند در جلسه ۱۶۰۰ مورخ ۱۳۹۳/۶/۹ هیأت مدیره، نامه شماره گ/۰۰۰/۹۰۸۱/۵۵ مورخ ۱۳۹۳/۴/۲۱ مدیر پژوهش و فناوری و رئیس شورای استاندارد در مورد تصویب نهایی استاندارد تحت عنوان مشخصات کیفی گاز طبیعی ایران به شماره استاندارد (1) IGS-M-CH-033 مطرح و با تأکید موارد ذیل مورد تصویب قرار گرفت:

۱- شرکت‌های پالایش گاز و شرکت‌های تابعه شرکت ملی نفت ملزم به رعایت کیفیت استاندارد گاز تحویلی به شبکه خطوط لوله در خروجی پالایشگاهها و خروجی کارخانه‌های گاز و گاز مایع می‌باشند.

۲- شرکت انتقال گاز ملزم به رعایت کیفیت استاندارد گاز در مبادی تحویل به شرکت‌های گاز استانی، مبادی صادراتی و مصرف کنندگان عمده می‌باشد.

۳- استاندارد موصوف به شرکت ملی صادرات گاز ارسال تا در قراردادهایی که از شبکه شرکت ملی گاز ایران صورت خواهد پذیرفت مورد استفاده قرار گیرد. ضمناً در صورت نیاز به تغییر برخی از مشخصات مذکور در قراردادهای صادرات و واردات، با هماهنگی با شرکت ملی گاز ایران امکان پذیر می‌باشد.

۴- استاندارد فوق به شرکت‌های زیرمجموعه وزارت نفت فعال در زمینه طراحی و ساخت پالایشگاه‌های آتی ارسال تا در صورتیکه گاز خروجی آنها به شبکه انتقال شرکت ملی گاز ایران اتصال خواهد یافت مورد استفاده قرار گیرد.

۵- تطابق، نظارت و کنترل کیفیت گاز تحویلی در خروجی پالایشگاهها و مبادی مصرف برعهده مدیریت دیسپچینگ می‌باشد.

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FOREWORD

This standard is intended to be mainly used by NIGC and contractors, and has been prepared based on interpretation of recognized standards, technical documents, knowledge, backgrounds and experiences in natural gas industry at national and international levels. Iranian Gas Standards (IGS) are prepared, reviewed and amended by technical standard committees within NIGC Standardization division and submitted to the NIGC's "STANDARDS COUNCIL" for approval. IGS Standards are subject to revision, amendment or withdrawal, if required. Thus the latest edition of IGS shall be checked/inquired by NIGC employees and contractors.

This standard must not be modified or altered by NIGC employees or its contractors. Any deviation from normative references and / or well-known manufacturer's specifications must be reported to Standardization division.

The technical standard committee welcomes comments and feedbacks about this standard, and may revise this document accordingly based on the received feedbacks.

GENERAL DEFINITIONS:

Throughout this standard the following definitions, where applicable, should be followed:

- 1- "STANDARDIZATION DIV." is organized to deal with all aspects of industry standards in NIGC. Therefore, all enquiries for clarification or amendments are requested to be directed to mentioned division.
- 2- "COMPANY": refers to National Iranian Gas Company (NIGC).
- 3- "SUPPLIER": refers to a firm who will supply the service, equipment or material to NIGC whether as the prime producer or manufacturer or a trading firm.
- 4- "SHALL ": is used where a provision is mandatory.
- 5- "SHOULD": is used where a provision is advised only.
- 6- "MAY": is used where a provision is completely discretionary.

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INTRODUCTION

The specification for gas quality was first documented in 2004. This standard specification replaces the previous version. The main reasons for this technical revision were:

- Changes in composition of existing gas reservoirs;
- Development of new gas resources with different gas composition;
- Expansion of export and import of natural gas;
- Modification and revamping of existing gas treating plants.

This standard specification is the result of a remarkable effort made by a specialized committee consisting of representatives of different departments of National Iranian Gas Company and representatives of Research Institute of Petroleum Industry (RIPI).

The committee started with collecting information about:

- The latest edition of international standards, references, publications, and investigation results;
- Outlet gas specification of existing gas treating plants on design basis and experimental data
- Consumer's need

The group's activities during the period involved a detailed analysis of the relevant combustion and non-combustion parameters of gas quality in order to assess the impacts of quality variations on the safe operation of appliances and the integrity and operation of gas transportation infrastructure. This included comparison of the gas quality specifications with the experimental data so that we ensure past learnings are incorporated.

The conducted studies consider all areas of gas industry, including gas processing/conditioning, transmission, distribution, utilization, and strategies for environmental protection. The initial draft was then distributed to various department of NIGC to get their feedbacks.

Then the committee began to review the received feedbacks and revised the content of the mentioned draft.

NIGC has been supplying high quality natural gas to its consumers and a very important mission has been providing clean and non-pollutant gas to preserve air quality.

1. SCOPE

This standard covers specifications which are applied to:

- The natural gas delivered from gas treating plants to the pipeline networks, any point of pipeline transmission networks, and the designated points to main industries power plants and all CGS/TBS;
- Basis for designing future natural gas treating plants;
- Reference for export and/or import gas contracts.

Natural gas with the quality described in this standard specification may be used for:

- Residential consumption;
- Commercial consumption;
- Industrial utilization;
- Fuel in natural gas vehicles (CNG);
- As a feed for chemical or petrochemical complexes;
- As a reduction agent in steel industry;
- Natural gas appliances and equipment.

Natural gas complying with this standard specification would be safe (non-corrosive and non-toxic) and suitable for the aforementioned usages. However, it may not be necessarily suitable to other usages (not mentioned here).

This standard specification provides chemical composition, physical properties, test/calculation methods and interchangeability indices. Informative literatures are also supplied in Annexes.

Note 1: Specification of importing natural gas is subject to contractual requirements between buyer and seller and these may include agreed variations or excursion from this standard specification.

Note 2: Natural gas vehicles requiring compression to higher pressures than the maximum transmission pressure may require to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

Note 3: This standard specification does not cover the existing export contracts.

2. SIGNIFICANCE AND USE

The objective of this standard specification is to provide buyers, transporters, and industrial/residential consumers of natural gas with a product that is safe to use and handle, and to provide quality assurance for designers and manufacturers of appliances, equipment, and vehicles which use natural gas. Also, this standard specification is useful for designers of natural gas treating plants that choose processes to achieve the gas quality described in this standard specification.

3. REFERENCES

Documents referred to in this standard specification are listed in Section 3.1 as normative references.

For additional information on natural gas characteristics in this standard specification, refer to documents listed in Annex G.

3.1 Normative References

Throughout this standard specification the following standards are referred to. The editions of these standards that are in effect of the time of issuing this standard specification (2014) shall form part of this standard specification. The applicability of changes in standards that occur after the date of this standard specification shall be mutually agreed upon by the NIGC and the buyers and/or consumers.

ASTM D 1072 (2006) "Test Method for Total Sulfur in Fuel Gases by Combustion and Barium Chloride Titration"

ASTM D 1142 (2006) "Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew-Point Temperature"

ASTM D 1826 (2003) "Test Method for Calorific (Heating) Value of Gases in Natural Gas Range by Continuous Recording Calorimeter"

ASTM D 1945 (2003) "Test Method for Analysis of Natural Gas by Gas Chromatography"

ASTM D 1988 (2006) "Test Method for Mercaptans in Natural Gas Using Length-Of-Stain Detector Tubes"

ASTM D 3588 (2003) "Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels"

ASTM D 4084 (2007) "Test Method for Analysis of Hydrogen Sulfide in Gaseous Fuels (Lead Acetate Reaction Rate Method)"

ASTM D 4810 (2006) "Test Method for Hydrogen Sulfide in Natural Gas Using Length-of-Stain Detector Tubes"

ASTM D 4984 (2006) "Test Method for Carbon Dioxide in Natural Gas Using Length-Of-Stain Detector Tubes"

ASTM D 5287 (2002) "Practice for Automatic Sampling of Gaseous Fuels"

ASTM D 5454 (2004) "Test Method for Water Vapor Content of Gaseous Fuels Using Electronic Moisture Analyzers"

ASTM D 6228 (2003) "Test Method for Determination of Sulfur Compounds in Natural Gas and Gaseous Fuels by Gas Chromatography and Flame Photometric Detection"

ASTM D 6667 (2004) "Test Method for Determination of Total Volatile Sulfur in Gaseous Hydrocarbons and Liquefied Petroleum Gases by Ultraviolet Fluorescence"

GPA 2261 (1999) "Analysis for Natural Gas and Similar Gaseous Mixture by Gas Chromatography"

GPA 2286 (1995) "Tentative Method of Extended Analysis for Natural Gas and Similar Gaseous Mixture by Temperature Programmed Gas Chromatography"

UOP 212 (2009) "Test Method for Determination of Hydrogen Sulfide and Mercaptan Sulfur in Hydrocarbon Gases by Potentiometric Titration"

4. DEFINITIONS

For the purposes of this standard specification, the following definitions and explanations apply.

4.1 Natural Gas

Natural gas is a gaseous form of petroleum obtained from underground sources and consisting of a complex mixture of hydrocarbons, primarily methane, but generally also including ethane, propane and higher hydrocarbons in much smaller amounts. It generally also includes some inert gases, such as nitrogen and carbon dioxide, plus minor amounts of trace constituents.

Natural gas remains in the gaseous state under the temperature and pressure conditions normally found in service. It is produced by processing raw gas or from liquefied natural gas and, if required, blended to give a gas suitable for direct use.

In this standard specification natural gas means the natural gas delivered from gas treating plants to the pipeline networks.

4.2 Liquefied Natural Gas (LNG)

LNG is natural gas that has been liquefied for storage or transportation purposes. Liquefied natural gas is revaporized and introduced into pipelines for transmission and distribution as natural gas.

4.3 Compressed Natural Gas (CNG)

CNG is highly compressed (though not liquefied) natural gas in high-pressure containers that is used extensively as fuel for automobiles, trucks, and buses. Small amounts of natural gas are also transported overland in high-pressure containers.

4.4 Substitute Natural Gas

Manufactured or blended gas with properties that makes it interchangeable with natural gas. Substitute natural gas is sometimes called synthetic natural gas.

4.5 Raw Gas

Unprocessed gas taken from well heads through gathering lines to gas treating plants.

4.6 Inert Gas

Component that exists predominantly in a gaseous state at standard conditions and which does not contribute to the measured heating value of the gas. Inert gas includes but is not limited to carbon dioxide, nitrogen, oxygen and noble gases.

Note: It is recognized that oxygen is not chemically inert, but as a component of natural gas, it acts to dilute the hydrocarbon content and does not add to the measured heating value.

4.7 Oil

Hydrocarbon and other liquids that is non-volatile at atmospheric conditions.

NOTE: Oil is likely to consist principally of compressor lubricating and seal oil but can include other liquids such as glycol and heavy components of gas condensates.

4.8 Local Distribution System

The gas mains and services which supply natural gas directly to consumers.

4.9 Gas Quality

The quality of a natural gas is defined by its composition and the following physical properties:

Calorific value, Wobbe Index, Density, Compression factor, Relative density, Dew points.

4.10 Standard Conditions

The preferred reference conditions are referred to as standard reference conditions and denoted by the subscript "s" (see ISO 13443):

Ps = 101.325 kPa Standard Pressure

Ts = 15.56 °C (60 °F) = 288.71 K Standard Temperature

4.11 Normal Conditions

The conditions are referred to as normal conditions and denoted by the subscript "n":

Pn = 101.325 kPa Normal Pressure

Tn = 0° C = 273.15 K Normal Temperature

4.12 Heating Values

It is divided into two types: Higher heating value and Lower heating value, defined as follows (see ISO 6976).

4.12.1 Higher heating value

The amount of heat which would be released by the complete combustion in air of a specified quantity of gas, in such a way that the pressure at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature as that of the reactants, all of these products being in the gaseous state except for water formed by combustion, which is condensed to the liquid state at the above mentioned temperature. The above mentioned pressure and temperature must be specified.

Note: Higher heating value is also known as 'gross heating value' or 'superior heating value'.

4.12.2 Lower heating value

The amount of heat which would be released by the complete combustion in air of a specified quantity of gas, in such a way that the pressure at which the reaction takes place remains constant, and all the products of combustion are returned to the same specified temperature as that of the reactants, all of these products being in the gaseous state.

The above mentioned pressure and temperature must be specified for both higher and lower heating values, which differ by the heat of condensation of water formed by combustion, can be specified on a molar, mass or volumetric basis. For the volumetric basis the pressure and temperature shall be stated at standard reference conditions calorific values can also be stated as dry or wet, depending on the water vapor content of the gas prior to combustion. Normally, the heating value is expressed as the higher heating value, dry value specified on a volumetric basis under standard reference conditions.

Note: Lower heating value is also known as 'net heating value' or 'inferior heating value'.

The difference between 'higher heating value' and 'lower heating value' is in the latent heat of condensation of water vapor produced during combustion.

4.13 Density

The mass of a gas divided by its volume at specified pressure and temperature.

4.14 Relative Density

Often called specific gravity, it is the mass of natural gas, dry or wet, per unit volume divided by the mass of an equal volume of dry air; both at the same specified pressure and temperature (see ISO 6976).

4.15 Wobbe Index

The Wobbe Index is a measure of the heat input to gas appliances, derived from the orifice flow equation. It is defined as the higher heating value of the gas, always on a volume basis, divided by the square root of the corresponding relative density. The heat input for different natural gas compositions is the same if they have the same Wobbe Index and are used under the same gas pressure (see ISO 6976).

4.16 Compression Factor

The compression factor Z is the quotient of the volume of an arbitrary mass of gas, at a specified pressure and temperature, and that of the same gas under the same conditions as calculated from the ideal gas law the terms compressibility factor and Z -factor are synonymous with compression factor (see ISO 12213-1).

4.17 Cricondenbar

The highest pressure at which liquid and vapor phased can exist at equilibrium in a multi component system.

4.18 Cricondenthem

The highest temperature at which liquid and vapor phased can exist at equilibrium in a multi component system.

4.19 Critical Temperature

For a pure component, the maximum temperature at which the component can exist as a liquid. Above this temperature, the fluid is a gas and cannot be liquefied regardless of the pressure applied.

4.20 Critical Pressure

The vapor pressure of a substance at its critical temperature.

4.21 Critical Density

The density of a substance at its critical temperature and critical pressure.

4.22 Retrograde Region

That area inside phase envelope where condensation of liquid occurs by lowering pressure or increasing temperature.

4.23 Retrograde Condensation (Vaporization)

Condensation or vaporization that is the reverse of usual behavior. Condensation caused by a decrease in pressure or increase in temperature. Vaporization caused by an increase in pressure or decrease in temperature can only occur in mixtures.

4.24 Dehydration

The act or process of removing water from gases or liquids.

4.25 Hydrate

A hydrate is a solid formed by the physical combination of water molecules and certain of the molecules contained in gas. It is solid like true ice but processes different characteristics.

4.26 Dew Point

The temperature at any given pressure, or pressure at any given temperature, at which liquid initially condenses from a gas or vapor. It is specifically applied to the temperature at which water vapor starts to condense from a gas mixture (water dew point), or at which hydrocarbons start to condense (hydrocarbon dew point).

4.26.1 Water Dew Point

The dew point defines the temperature above which no condensation of water occurs at a specified pressure.

For any pressure lower than the specified pressure there is no condensation of water vapor at this temperature (see ISO 6327).

4.26.2 Hydrocarbon Dew Point

The dew point defines the temperature above which no condensation of hydrocarbons occurs at a specified pressure at a given dew point, there is a pressure range within which condensation occurs except at one point, the cricondentherm.

4.27 Total Sulfur

Total amount of sulfur found in natural gas.

Note: The total amount of sulfur, both organic and inorganic i.e. hydrogen sulfide, sulfur oxides, mercaptans, carbonyl sulfides, ... , may be determined by an analytical method not differentiating between individual sulfur compounds combustion methods.

4.28 Molar Composition

The molar composition of a gas is the term used when the proportion of each component is expressed as a molar (or mole) fraction, or molar (mole) percentage, of the whole thus the mole fraction, x_i , of component i is the quotient of the number of moles of component i and the number of moles of the whole mixture present in the same arbitrary volume. One mole of any chemical species is the amount of substance which has the relative molecular mass in grams. A table of recommended values of relative molecular masses is given in ISO 6976. For an ideal gas, the mole fraction (or percentage) is identical to the volume fraction (percentage), but this relationship cannot in general be assumed to apply to real gas behavior.

4.29 Gas Composition

The concentrations of the major and minor components and trace constituents in natural gas as analyzed.

- The major components of a gas are specified as volumetric, molecular or mass proportions in percentage. They also determine the allocation of the fuel gases to the gas families.
- The minor components of a gas can be present as a gas, liquid or solid. The concentration is specified in mg/m^3 , cm^3/m^3 (also vppm), mg/kg (also ppm) for the majority of gas secondary substances, or a specification can be used which relates to the behavior of the gas during transport.

4.30 Gas Analysis

The use of test methods and other techniques for determining the gas composition, as stated in this standard specification.

4.31 Limit

The value beyond which the specified characteristic or concentration of the component is not permitted to vary.

4.32 Maximum Allowable Operating Pressure (MAOP)

The maximum pressure at which a pipeline may be operated.

4.33 Interchangeability

A measure of the degree to which the combustion characteristics of one gas resemble those of another gas. 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. Interchangeability can be defined as the ability of a distributed natural gas to be substituted by another without the need for adjustment at the customers' equipment. The appliances will continue to operate safely and satisfactorily.

The criteria to be considered for interchangeability are as follows:

Thermal input: Flow of gas through an orifice at constant pressure, a function of Wobbe Index.

Flash back: The tendency for the flame to contract towards the port and for the combustion to take place inside the burner.

Lifting: Burning surface expands to the point where burning ceases at the port and burns above it.

Yellow Tipping: Incomplete combustion where excess hydrocarbons could, but does not always, results in unacceptable levels of carbon monoxide. It may result in soot deposition and a continuing deterioration of combustion.

The substituted gas may be deemed to be interchangeable when, without the need for adjustment of the appliances, it provides a thermal input comparable with that provided by the gas previously distributed, without the occurrence of flash back, lifting or yellow tipping.

For the examination of the interchangeability there are two routes which can be followed, namely:

Wobbe index or gas composition based prediction methods.

4.34 Odorization

Natural gas is normally odorless. It is necessary to add an odorant to the gas fed into the distribution system for safety reasons. It permits the detection of the gas by smell at very low concentrations.

Note: It is a common requirement that natural gas in air be readily detectable by smell at a concentration of 20% of the lower flammability limit (LFL). The LFL of natural gas is normally taken as volume content in air of 4% to 5%.

4.35 Methane Number

The methane number is a rating indicating the knocking characteristics of a fuel gas. It is comparable to the octane number for petrol the methane number expresses the volume percentage of methane in a methane/hydrogen mixture which, in a test engine under standard conditions, has the same tendency to knock as the fuel gas to be examined.

4.36 Water Content

Mass concentration of the total amount of water contained in a gas.

Note 1: Water content is expressed in grams per cubic meter.

Note 2: For raw gas, this means water in the forms of both liquid and vapor, but for pipeline gas this means only water vapor.

4.37 Optimal Specification

Natural gas to be delivered under a contract at the delivery point, complies with the properties, condition and composition as set out in column "OPTIMAL" of the Table 3 shall be the optimal specification.

4.38 Acceptable Specification

Natural gas (other than optimal specification gas) to be delivered under a contract at the delivery point, complies with the properties, condition and composition as set out in column "ACCEPTABLE" of the Table 3 shall be the acceptable specification.

4.39 Resumption Specification

Natural gas (other than optimal specification gas and acceptable specification gas) to be delivered under a contract at the delivery point, complies with the properties, condition and composition as set out in column "RESUMPTION" of the Table 3 shall be the resumption specification.

5. REQUIREMENTS

This clause deals with the various Tables which shall be referred to in a designation of the quality of natural gas. The Tables actually selected will depend upon the purpose for which the designation is required.

5.1 Properties

5.1.1 The typical specification for natural gas component is shown in the Table A.1 (informative). The controlled specifications for natural gas for different purposes are provided in Tables 1, 2 and 3.

Note: For some of the components of natural gas, there is no specific limitation and the composition of these components depend on reservoir behavior and controlling processes that are different in gas treating plants. The specified specification consider as typical specification for Iranian gas treating plants.

The chemical composition which is restricted in natural gas treating plants regard as controlled specification.

5.1.2 The controlled properties for outlet of gas treating plants, pipeline networks and delivery to customers shall be complied with Table 1 when tested in accordance with test methods specified.

5.1.3 The gas treating plants shall be designed according to properties given in Table 2 according to specified test methods. The relative test methods are specified for any properties. This Table deals future import contracts too.

5.1.4 The chemical and physical properties for export pipeline quality natural gas shall be conformed to the requirements specified in Table 3 when determined by test methods listed in this Table.

5.2 Contaminants

The gas shall not contain any materials, dust, and other solid or liquid matter, waxes, gums, gum forming constituents, and unsaturated or aromatic hydrocarbons to an extent which might cause damage to, or interfere with the proper operation of, pipes, meters, regulators, control systems, equipment or appliances or which might cause the gas to be harmful or toxic to persons having contact with it in normal work operations or usage; also natural gas shall be technically free of following materials particularly.

Note: Technically free means that there are no visible traces of the components mentioned under actual conditions and they are sufficiently removed to ensure the operation of gas appliances and technical gas equipment of standard or normal construction.

5.2.1 Solid particulate substances in amounts deleterious to the materials normally encountered in transportation and utilization. Solid particle size of natural gas should meet equipment manufacturer recommendations.

5.2.2 Water and unsaturated or aromatic hydrocarbons in liquid form, to an extent that causes unacceptable sooting.

5.2.3 Other gases that could adversely affect the transportation or utilization of the gas.

5.3 Odorization

Odorizing of natural gas where applicable is provisional if required by contract terms as per IGS standards as follows:

IGS-PM-100(0) "Odorizer, Bypass Type"

IGS-M-PM-101(0) "Odorizer, Injection Type"

IGS-M-PM-102(0) "Odorizer, Meter Driven Type"

5.4 Sampling

The sampling shall be carried out in accordance with ASTM D 5287.

TABLE 1 – Specification Limits for Natural Gas Component – Outlet of Gas Treating Plants (GTP), Pipeline Networks and Delivery to Customers

Item	Component	Unit	Minimum	Maximum	Test Methods	Remark
1	Hydrogen Sulfide (H ₂ S)	mg/Sm ³	---	5.0	ASTM D 6228 ASTM D 4810 ASTM D 4084	(1)
2	Mercaptan Sulfur (R-SH) not including odorization of natural gas	mg/Sm ³	---	15.0	ASTM D 6228 ASTM D 1988 UOP 212	---
3	Total Sulfur (daily average) including H ₂ S and R-SH and not including odorization of natural gas	mg/Sm ³	---	30.0	ASTM D 6667 ASTM D 1072	(2)
4	Carbon Dioxide (CO ₂)	mol%	---	2.0	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261	---
5	Total Inert Gas (CO ₂ + N ₂)	mol%	---	7.0	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261	---
6	Water Dew Point / Water Content	---	---	Dew point -10 °C at any GTP outlet delivery pressure and at any line pressure and in any case no more than 110 mg/Sm ³	ASTM D 5454 ASTM D 1142	---
7	Hydrocarbon Dew Point	(°C)	---	-7 °C at any line pressure	ASTM D 1142	(3)
8	Higher Heating Value	MJ/Sm ³ (kcal/Sm ³)	35.59 (8500)	43.96 (10500)	ASTM D 1826 ASTM D 3588	---
9	Wobbe Index (based on higher heating value)	MJ/Sm ³ (kcal/Sm ³)	46.05 (11000)	52.34 (12500)	---	---

(1): The H₂S value for Shahid Hasheminejad Gas Treating Plant may be maximum 5.7 mg/ Sm³.

(2): Total sulfur of gas shall have a maximum normal operation level of 30 mg/Sm³. However under unusual circumstances this level may be exceeded up to a maximum of 100 mg/Sm³ provided that the weighted daily average of total sulfur not exceeded the level of 30 mg/Sm³.

(3): The hydrocarbon dew point for outlet of existing gas treating plants shall be conformed to the requirements specified in Table B.1 / Equation B.1 (ANNEX B).

TABLE 2 – Specification Limits for Natural Gas Component – Design of New Gas Treating Plant (GTP) and Future Import Contracts⁽¹⁾

Item	Component	Unit	Minimum	Maximum	Test Methods	Remark
1	Hydrogen Sulfide (H ₂ S)	mg/Sm ³	---	5.0	ASTM D 6228 ASTM D 4810 ASTM D 4084	---
2	Mercaptan Sulfur (R-SH)	mg/Sm ³	---	6.0	ASTM D 6228 ASTM D 1988 UOP 212	---
3	Total Sulfur (daily average)	mg/Sm ³	---	30.0	ASTM D 6667 ASTM D 1072	---
4	Carbon Dioxide (CO ₂)	mol%	---	2.0	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261	---
5	Total Inert Gas (CO ₂ + N ₂)	mol%	---	7.0	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261	(2)
6	Water Dew Point / Water Content	---	---	Dew point -15 °C at any GTP outlet delivery pressure and at any line pressure (in any case no more than 50 mg/Sm ³)	ASTM D 5454 ASTM D 1142	---
7	Hydrocarbon Dew Point	(°C)	---	-10 at cricondenthem pressure	ASTM D 1142	---
8	Higher Heating Value	MJ/Sm ³ (kcal/Sm ³)	35.59 (8500)	43.96 (10500)	ASTM D 1826 ASTM D 3588	---
9	Wobbe Index (based on higher heating value)	MJ/Sm ³ (kcal/Sm ³)	46.05 (11000)	52.34 (12500)	---	---

(1): Specification of importing natural gas is subject to contractual requirements between buyer and seller and these may include agreed variations or excursion from this standard specification.

(2): For the reservoir that the N₂ composition not meets the requirements of this standard specification to achieve the specified value before any design study it shall be required feasibility study including removal process, local consumption, mix with other gases, etc.

TABLE 3 – Controlled Specification for Natural Gas Component – Export Contracts

Item	Component	Unit	Optimal	Acceptable	Resumption	Test Methods
1	Hydrogen Sulfide (H ₂ S)	mg/Sm ³	max 5	max 6	max 7	ASTM D 6228 ASTM D 4810 ASTM D 4084
2	Total Sulfur (daily average)	mg/Sm ³	max 45 (1)	max 50 (1)	max 50 (1)	ASTM D 6667 ASTM D 1072
3	Carbon Dioxide (CO ₂)	mol%	max 2	max 2.2	max 2.5	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261
4	Total Inert Gas (CO ₂ + N ₂)	mol%	max 7	max 7.5	max 8	ASTM D 1945 ASTM D 4984 GPA 2286 GPA 2261
5	Water Content	mg/Sm ³	max 112	max 130	max 150	ASTM D 5454 ASTM D 1142
6	Hydrocarbon Dew Point (at any gas treating plant delivery pressure and any line pressure)	(°C)	max -7	max -5	max -0.1	ASTM D 1142
7	Gross Heating Value	MJ/Sm ³ (kcal/Sm ³)	min 34.75 (8300) max 43.96 (10500)			ASTM D 1826 ASTM D 3588
8	Wobbe Index	MJ/Sm ³ (kcal/Sm ³)	min 46.05 (11000) max 52.34 (12500)			---

(1): Total sulfur of gas shall have a maximum normal operation level of 45 mg/Sm³. However under unusual circumstances this level may be exceeded up to a maximum of 100 mg/Sm³ provided that the weighted daily average of total sulfur not exceeded the level of 45 mg/Sm³ on optimal conditions and 50 mg/Sm³ on acceptable and resumption conditions.

ANNEX A

Specification for Natural Gas Components (Informative)

The chemical composition of natural gas depends on reservoir behavior and generally for some of the below components there is no specific controlling process in gas refineries. Hence, this chemical composition shall be considered as typical and not exact. But in case of any changes in the below compositions, the higher heating value shall be supplied based on Tables 1, 2 and 3.

TABLE A.1 – Typical Specification for Natural Gas Component

Item	Component	Unit	Minimum	Maximum	Test Methods
1	Methane (CH ₄)	mol%	80.00	---	ASTM D 1945 GPA 2286 GPA 2261
2	Ethane (C ₂ H ₆)		---	7.00	
3	Propane (C ₃ H ₈)		---	3.00	
4	Butanes (C ₄)		---	1.00	
5	Pentanes and Heavier (C ₅ ⁺)		---	0.50	

ANNEX B
Specification of Hydrocarbon Dew Point for Outlet of Existing GTP's
(Normative)

The hydrocarbon dew point for outlet of existing gas treating plants shall be conformed to the requirements specified in Table B.1 / Equation B.1.

TABLE B.1 – Hydrocarbon Dew Point for Outlet of Existing Gas Treating Plants (GTP's)

Pressure (barg)	Hydrocarbon Dew Point (HCDP) °C
Less Than 50	-7
56	-10
60	-11
65	-13
70	-15
75	-17
80	-20
85	-24
More Than 85	-30

For other pressures between 50 to 85 barg that not mentioned in Table B.1 it may calculate by the following equation (Eq. B.1).

$$\text{HCDP (}^{\circ}\text{C)} = - 0.008 P^2 + 0.6417 P - 20.5447 \quad (P=\text{barg}) \quad \text{Eq. B.1}$$

ANNEX C

Derivation of Specification (Informative)

C.1 Background

Any known composition of Iranian natural gas so far, can be regarded as ordinary natural gas. This standard specification describes the range of natural gas to be used for aforementioned purposes. No attempt has been made to define the exact composition of the gas beyond those compounds normally regarded as gas contaminants, which have a detrimental effect on the properties of the gas. Most of the specification limits in this document are presented in details with studies approach and investigations results. Normative specification limits on particular characteristics and components of the gas are presented in Tables 1 to 3 of this document, while more information on those characteristics and components and on other contaminants is provided further in this Annex. This standard specification does not cover other gases such as LPG/air mixture and synthetic natural gas.

C.2 Limits

Achieving a balance between optimum performance and cost of supply is essential in any natural gas specification. For resolving this problem the limits are set as wide as possible while still maintaining safe combustion performance. Both safety and performance may be compromised when the specification of supplied natural gas deviates from these limits.

C.3 Characteristics and Components

C.3.1 Wobbe Index

Wobbe Index is a measure of the energy input rate to a burner at constant supply pressure and also relates to the combustion characteristics of the burner. A change in the Wobbe Index of the gas will result in a proportional change in the energy output of all gas appliances and equipment supplied, and in the energy carrying capacity of gas pipelines and distribution networks. Fuel gases of various compositions with the same Wobbe Index produce almost the same heat load at the burner under the same pressure (flow pressure).

The permissible range of Wobbe Index is the range over which the present Iranian population of gas appliances and equipment can be expected to operate safely.

Appliances adjusted on the reference gas, at the normal pressure, and judged to perform satisfactorily with the limit gases at the test pressures, are approved for use within all natural gas resources. In this approach the Wobbe Index is the primary gas parameter.

The Wobbe Index of a gas is an indicator of its combustion acceptability for a given population of appliances and is the most significant parameter in terms of gas combustion safety. The Wobbe Index is calculated by dividing the higher heating value (or gross calorific value) by the square root of the relative density of the gas.

In all gas appliances, the flow of gas is regulated by making it flow through a hole or orifice of given size at a constant pressure. The higher the Wobbe Index of a gas, the greater the heating value of the quantity of gas that will flow through an orifice of a given size in a given amount of time.

The Wobbe Index is therefore an indicator of the rate of heat flow from the burner. Too high a Wobbe Index can result in the over-heating of appliances, or sooting and carbon monoxide (CO) formation due to incomplete combustion and consequently present increased risk of deaths by poisoning. Too low a Wobbe Index can result in flame lift, becoming unstable or even extinguishing of flames, resulting in the release of unburned flammable gas. With respect to gas-fired power generating plant, Wobbe Index is a critical factor for generator combustion dynamics.

UK Gas Quality Programme

During 2005 a major test exercise was performed on behalf of the UK Government Department BERR to examine the variation in combustion performance of a range of representative domestic gas appliances working at the extremes of the EASEE-gas Wobbe Index limits and beyond. Some 25 appliances were tested representing about 70% of the UK gas appliance population. The following data was collected from the appliances operating under different gas qualities:

- CO emissions;
- CO₂ emissions;
- CO/ CO₂ ratio;
- NO_x emissions;
- Air Factor from CO₂ and O₂ measurements in flue gas;
- Surface temperature of appliance at three locations (minimum);
- Particulate matter measurements in flue gas;
- Flue gas temperature;
- Derive thermal efficiency of appliance (flue loss method);
- Record any changes in the performance of safety devices;
- Record any changes in ignition characteristics; and
- Fuel leakage measurement from appliance exhaust.

A typical graph of test results is shown below for a wall-hung condensing boiler.

The conclusions from this work were:

- Tests within Wobbe Index 47.2 – 51.4 MJ/m³ (GS(M)R) resulted in acceptable performance;
- Exponential increase in CO emissions are seen at Wobbe Index beyond 53 MJ/m³; and
- There is a potential for badly maintained appliances to produce CO levels that may cause risk to consumer safety.

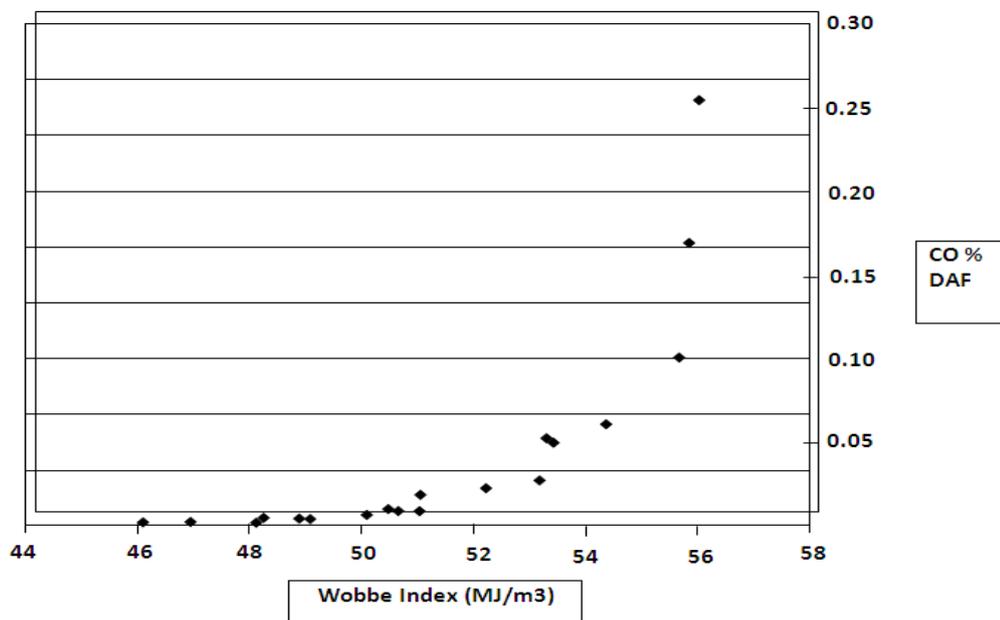


Figure C.3.1

Generally the test gases within the range of Wobbe Numbers from 45 to 52 MJ/m³ resulted in acceptable appliance operability compared with current standards for G20 (pure methane) reference gas. Increasing the Wobbe Number of the gas used will almost certainly increase the emission level of carbon monoxide. Whilst the levels produced from the appliances tested in this program were on the whole modest, except for Wobbe Number gases >53 MJ/m³, there is the potential for badly maintained or installed appliances to produce CO levels that may cause an increasing overall health risk.

C.3.2 Higher Heating Value

A maximum higher heating value of 43.96 MJ/Sm³ (10500 kcal/Sm³) is required by this specification. Gases with higher heating values greater than this limit have an unacceptably higher propensity for incomplete combustion and sooting, which would not necessarily be detected by tests using existing appliance standard limit gases.

C.3.3 Relative Density

Relative density is limited to a maximum of 0.70 in order to control risk of sooting. The basis for our selection of this value is as follows:

- Sooting is associated with the presence of higher hydrocarbons and relative density correlates well with higher hydrocarbon content.
- Studies carried out by Marcogaz working group to correlate UK parameters with relative density indicate that sooting limit considerations are not significant below a relative density of 0.70.

-. Known or anticipated sources of gases with relative density greater than 0.70 are assumed to be consumed locally only and not feature in cross-border trade. A period of consultation within the gas industry is recommended to confirm this.

C.3.4 Hydrogen Sulfide

Hydrogen sulfide is a colorless flammable gas which has an offensive odor similar to rotten eggs. It is extremely poisonous. Unfortunately the human system adapts readily to H₂S odor so that increasing concentrations may not be noticed. High concentrations of H₂S result in rapid poisoning and death. In many cases it is necessary from a health and safety standpoint.

Hydrogen sulfide is a corrosive gas and its corrosion effect on pipelines and copper components in gas installations tends to be cumulative. H₂S is also a stress corrosion cracking agent for carbon steel pipeline and the likelihood of creating stress cracks is dependent on the partial pressure of the hydrogen sulfide in as much that at higher gas pressure, a lower level of H₂S must be specified.

In the presence of water, hydrogen sulfide can cause hydrogen induced cracking and sulfide stress cracking in high tensile steels at high pressure. This is of particular importance for transportation of gas in steel pipes and for the use of natural gas in vehicles where natural gas is typically stored at pressure up to 26 MPa. By dehydrating, corrosion by H₂S is effectively eliminated. Similarly the potential for corrosion acid gas can also be controlled by dehydration.

Hydrogen sulfide has also been associated with chemical attack on copper and its alloys leading to the formation of copper sulfide, which can cause malfunctions in appliances, including the blockage of pilot jets.

In general the limitation of hydrogen sulfide in natural gas is important because of the gas quality specifications, the corrosive nature of H₂S on pipeline materials and the effects of hydrogen sulfide on utilization equipment. Hydrogen sulfide removal is desirable to reduce its detrimental effects.

C.3.5 Total Sulfur

Many sources of natural gas contain varying amounts and types of sulfur compounds, which are odorous, corrosive to equipment and can inhibit or destroy catalyst in gas processing. Their accurate amount is essential to gas processing, operation and utilization.

This parameter is the quantity of sulfur contained in the sulfur containing compounds that are present in natural gas. The limitation is related to air pollution and indoor air quality control. Furthermore the sulfur content of gases adversely affects the life of pipelines and consumer appliances, it is therefore limited for all fuel gases.

The sulfur content of natural gas, used for fuel proposes contributes to SO_x emissions and can lead to corrosion in appliances, engine and exhaust systems. Sulfur compounds in the gas may also lead to the deposition of elemental sulfur in pipelines, which also have a corrosive effect particularly in the presence of water. The sulfur compounds may have a very strong and unpleasant smell and may lead to nuisance leak reports. Some process catalysts used in petroleum and chemical refining can be poisoned by sulfur bearing materials in the feed stocks. Additionally, certain industrial processes, e.g. glass manufacturers, may be adversely affected by high sulfur content in the gas stream.

With the widespread use of flueless heating and increasing awareness of air quality it is highly desirable that the sulfur content of natural gas be kept as low as possible.

C.3.6 Water Dew Point

Natural gas and associated condensate are often produced from the reservoir saturated (in equilibrium) with water.

Liquid phase water can cause corrosion and the formation of gas hydrates and condensation of free water in transmission systems. In combination with hydrogen sulfide and carbon dioxide, water can also lead to stress corrosion cracking and hydrogen embrittlement.

The stated limits are designed to ensure that hydrate formation and excessive corrosion do not occur in transmission systems.

For application such as natural gas vehicles requiring compression to higher pressure than the maximum transmission pressure it may be necessary to use a gas dryer to remove moisture from the gas to prevent liquid water or hydrate formation.

The temperature of the gas stream must be maintained at a level sufficiently above the water dew point temperature to avoid liquid water formation in pipelines. When the water content in gas is determined, the water dew point at any pressure is obtained from figures (see Annex F). Also ISO 18453 specifies a method to provide users with a reliable mathematical relationship between water content and water dew point when one of two is known.

Note: Above mentioned figures are made available from Gas Conditioning and Processing Handbook – Volume 2, Campbell Petroleum Series, 1984.

C.3.7 Hydrocarbon Dew Point

The hydrocarbon dew point controls the level of heavy hydrocarbons in the gas (C3 upwards). These compounds are of concern because at the high pressure used in both gas transmission and CNG storage condensation of heavy hydrocarbons may occur at low temperatures. The liquid hydrocarbon must be removed from natural gas because of following reasons:

- The high amount of liquid hydrocarbons can cause pressure drop and decrease the flow capacity of pipeline.
- Liquid hydrocarbons can collect and form slugs which can travel along pipelines and potentially damage gas flow regulating and measurement equipment. Hydrocarbon liquids also cause odorant removal from the gas phase. The presence of both hydrocarbons and odorant in the liquid phase can cause degradation of the rubber components of pressure regulating installations.
- A high hydrocarbon dew point may mean a low Wobbe Index, which may cause flame abnormality. It can also cause increased carbon monoxide formation in surface combustion burners. Too high of a Wobbe Index may give rise to high levels of carbon monoxide in the combustion products of conventional appliances. It can also promote overheating.

-. The amount of the higher saturated and unsaturated as well as aromatic hydrocarbons in gases should be limited relative to the gas distribution and the burning behavior of the gases. The concentration permissible for a trouble-free combustion depends not only the type of hydrocarbons but also on the hydrogen and oxygen content of the gas. Carbon dioxide also favors the combustion of unsaturated and aromatic hydrocarbons in comparison to nitrogen, particularly in diffusion burners.

Generally, for a multi component mixture of substances, the phase envelope is similar to figure C.3.7. This phase curve is very sensitive to composition, which is the variable that reflects the thickness of diagram. In high pressure pipeline, liquid can be prevented by removing enough of the heavy hydrocarbons and to change the shape and position of the phase curve. Consider line I-J, and the points I and J represents inlet and outlet conditions of pipeline. When line I-J crosses the dew point curve, liquid will begin to condense in the line. From that point on, two-phase flow exists. If the composition is changed enough, then the dashed phase curve would be the outcome, in which case, no liquid will form in the pipeline because the dew point is not reached. Any liquid present would be due to carryover of liquid from separator or having a different composition from the one used to construct the phase curve.

At high pressures, condensation of heavy hydrocarbons may occur at low temperatures. The pressures and temperature specified do not guarantee the total absence of retrograde condensation. Additionally, retrograde condensation can occur in transmission systems at pressure lower than the MAOP. It is this phenomenon that effectively determines the maximum allowable limits of heavy hydrocarbons in natural gas. The pressure specified approximates the cricondenthem pressure which not typical in Iranian natural gases, and is usually within the range of 23 to 51 bar.

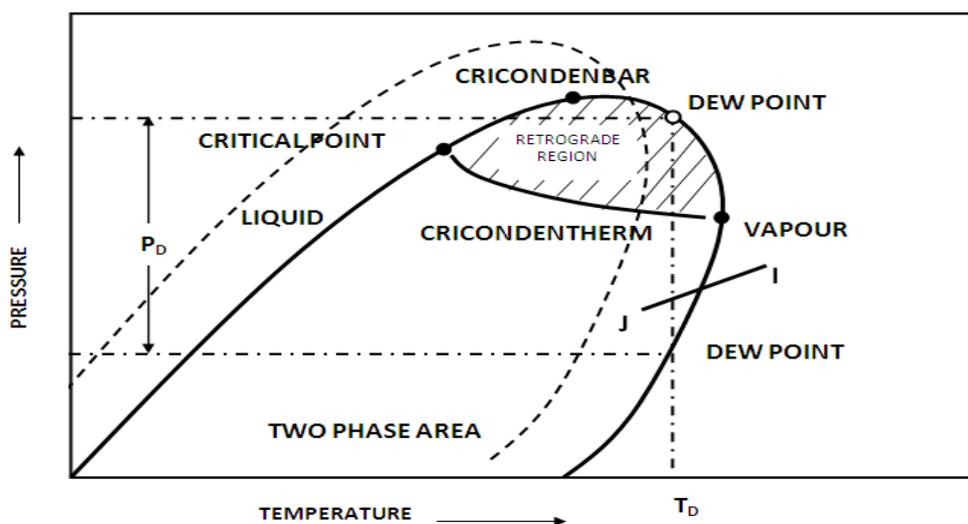


Figure C.3.7

C.3.8 Total Inert Gas

The specification for total inert gases is intended, in conjunction with the Wobbe Index limits, to limit the levels of higher hydrocarbons.

Carbon dioxide (CO₂) is classified as an "inert" along with other inert gases, principally Nitrogen (N₂) and to a lesser extent Helium (He) and Argon (Ar) that may be present in the gas stream. Inert gases by themselves do not create a safety hazard and the specification limit is a method of controlling the levels of non-methane hydrocarbons (ethane, propane, butane, etc.) so as not to exceed the specified Wobbe Index limits. Manufacturing plants that use natural gas as a feedstock may suffer adverse impacts to their processes where there are high carbon dioxide or nitrogen levels. High levels of CO₂ in particular could have significant implications for some gas consumers that have specific needs. However this is a commercial issue and, where necessary, would be specified in contracts.

C.3.9 Other Combustion Parameters

Other combustion parameters, e.g. sooting index, flame speed and lift index, were considered but not deemed necessary for inclusion in the specification.

ANNEX D

Other Contaminants (Informative)

This Annex is provided as a guideline, and is not part of the requirements of this standard specification.

D.1 Oil

Specifying a limit for oil is an acknowledgment that, whilst undesirable, it is almost inevitable that some oil will escape from filters and coalescers downstream from compressors and other facilities. The limit is intended to restrict oil accumulation in transmission systems to manageable quantities, and to avoid network operation and appliance safety problems in distribution systems.

There are currently no suitable real time methods for measurement of entrained oil. Compliance is verified by retrospective logging of oil collected from filters or other entrapment elements.

D.2 Metals

Due to the increasing use of gas turbines for electricity generation, most specification from turbine suppliers specify fuel limits for alkali metals such as sodium and lithium and other metals including lead and vanadium because of their effect on the life of turbine blades.

D.3 Oxygen

Oxygen is generally not present in significant quantities in producing gas fields. Its presence in natural gas is usually attributed either to contamination during transportation, processing, storage and distribution, or to air ballasting as a means of moderating the Wobbe Index. National limits vary widely across the world, reflecting different standards, custom and practice.

Oxygen in the presence of water vapor can cause corrosion within pipelines, and at very high levels has the potential for forming explosive mixtures.

The contribution made by the presence of trace levels of oxygen in the gas supply to the combustion process is negligible. Rather, the air-fuel ratio during combustion, that determines most of the associated emissions behavior, is governed by primary and secondary air entrainment as the gas leaves an appliance injector nozzle. The contribution made by oxygen in the gas supply to the fuel efficiency of gas appliances in the combustion process is also believed to be negligible.

Corrosion products from oxidation in steel pipelines have the effect of stripping the injected odorant from gas.

An oxygen concentration of no more than 0.1% is required, in New Zealand Specification (NZS 5542), for the preferred limit, but this is permitted to rise to 1.0% mole in the absolute limit provided the gas is not to be transported through steel pipeline at high and intermediate pressure.

D.4 Total Halogens

Many trace gas compounds which may be present in the gas do not affect the operation of gas equipment or the combustion process.

One exception, apart from compounds which contain sulphur, are those which contain halogens, e.g. chlorine, fluorine, bromine, etc. Halogens are containing compounds may be harmful to equipment and (in the case of unflued appliances) to health. The total halogen limits of 5 mg/m^3 is introduced principally to cover gas produced from landfill extraction and biogas. Halogens are not normally found in significant quantities in gas petroleum origin.

D.5 Mercury

Mercury is hazardous to human health if ingested, absorb through the skin or inhaled. Mercury can also cause "liquid metal embrittlement" and subsequent failure of aluminium alloys.

Commercially available mercury removal equipment for natural gas is quoted as being able to get down to $0.1 \text{ } \mu\text{g/m}^3$ from inlet concentration of $25 - 50 \text{ } \mu\text{g/m}^3$. The atmospheric concentration (depending on location) is generally around $0.02 \text{ } \mu\text{g/m}^3$ (but higher in some industrial centers).

The figure of $1 \text{ } \mu\text{g/m}^3$ in natural gas will not add significantly to the background level in indoor air, is technically feasible and, upon dilution of the combustion products, will lead to concentrations well below the occupational health exposure level.

D.6 Radioactivity

Radon is a chemically inert gas which produces radiation as it decays to polonium 218. Polonium 218 also then produces radiation as it decays to lead 214. This sequence of decay continues with the creation and decay of several different isotopes of polonium, lead and bismuth, and finally lead 206 which does not decay further.

Thus the decay products of radon can create heavy-metal dusts which may accumulate in pipelines, vessels, filters, etc. In systems where natural gas is known to contain radon, appropriate protective measures should be taken in dealing with dust accumulations. The differing rates of decay of the various isotopes mean that most of the radon-initiated dust will consist of isotopes of lead.

ANNEX E

Interchangeability (Informative)

Interchangeability can be defined as the ability of a distributed natural gas to be substituted by another without the need for adjustment at the customer's equipment. The appliances will continue to operate safely and satisfactorily.

The criteria to be considered for interchangeability are as follows:

Thermal input: Flow of gas through an orifice at constant pressure, a function of Wobbe Index.

Flash back: The tendency for the flame to contract towards the port and for the combustion to take place inside the burner.

Lifting: Burning surface expands to the point where burning ceases at the port and burns above it.

Yellow Tipping: Incomplete combustion where excess hydrocarbons could, but does not always, result in unacceptable levels of carbon monoxide. This may result in soot deposition and a continuing deterioration of combustion.

The substituted gas may be deemed to be interchangeable when, without the need for adjustment of the appliances, it provides a thermal input comparable with the provided by the gas previously distributed, without the occurrence of flash back, lifting or yellow tipping.

For the examination of the interchangeability there are two approaches: Wobbe Index or *gas composition* based prediction methods.

The A.G.A. Interchangeability program, catalogue No. XH 8810 uses Index Method based on A.G.A. Research Bulletin 36 "Interchangeability of other fuel gases with natural gas" (1952, 2nd edition), the Weaver Index Method, and the Knoy Constant techniques to determine compatibility of gases. All methods involve an adjustment gas and a substitute gas. The A.G.A. and Weaver Index methods require a complete analysis of gas components, but the Knoy constant method uses only the higher heating value and relative density. Only the A.G.A. Index method is covered for this explanation.

E.1 Equations to Determine Interchangeability Indices

The possibility of interchangeability, to mix or substitute one type of gas with another gas for any purposes (e.g. peak shaving), is determined by interchangeability indices. The indices and limits for natural gases in this standard specification (high methane) are given below.

I_F : Flash – back Index

$$I_F = \frac{k_s f_s \sqrt{h_s / 1000}}{K_a f_a} < 1.20$$

I_L : Lifting Index

$$I_L = \frac{k_a}{\frac{f_a a_s}{f_s a_a} (k_s - \log \frac{f_a}{f_s})} < 1.06$$

I_Y : Yellow Tip Index

$$I_Y = \frac{f_s a_a y_a}{f_a a_s y_s} > 0.8$$

Where:

A = air theoretically required for complete combustion, m³ per m³ of gas (cu ft per cu ft of gas)¹

a = 100 A/h – air theoretically required for complete combustion, m³ per 100 MJ of gas (cu ft per 100 BTU of gas)

d = specific gravity of gas (air = 1.0)

E = total inerts in gas mixture, mole percent

F = lifting constant¹

f = 1000 d^{0.5} / h = primary air factor

h = higher heating value of gas, MJ per m³ (BTU per cu ft)

K = F/d = lifting limit constant

O₂ = Oxygen in gas mixture, mole percent

T = yellow tip constant, m³ of air required to eliminate yellow tips per m³ of gas (cu ft of air required to eliminate yellow tips per cu ft of gas)¹

Y = 100 T/A + 7E – 26.3 O₂ = yellow tip limit, percent primary air

s and a = substitute gas and adjustment gas , respectively

Use of these equations requires knowledge of the chemical composition, heating value and specific gravity of the gases.

.....
¹ See Table E.1

TABLE E.1 – Interchangeability Constants¹

G		A	F	T
Analysis of Gas Decimal Volume		Air Required for combustion cu ft /cu ft of gas	Lifting Constant	Yellow Tip Constant
H ₂		2.38	0.6	0.0
CO		2.38	1.407	0.0
CH ₄		9.53	0.67	2.18
C ₂ H ₆		16.68	1.419	5.8
C ₃ H ₈		23.82	1.931	9.8
C ₄ H ₁₀		30.97	2.55	16.85
C ₂ H ₄		14.29	1.768	8.7
C ₃ H ₆		21.44	2.06	13.0
C ₆ H ₆		35.73	2.71	52.0
III*		19.65	2.0	19.53
O ₂		-4.76**	2.9	-4.76**
(Inerts)				
CO ₂			1.08	
N ₂			0.688	
Total	1.00			

*Representative analysis of 3 C₂H₄+1C₆H₆.

**Always negative. Subtract from total.

.....
¹ Interchangeability of other fuel gases with natural gas, American Gas Association Research Bulletin 36, 1946

Example:

GAS DESIGNATION	Composition, vol %				W _{ss} MJ/m ³	H _{ss} MJ/m ³	d _s	Type of Gas
	CH ₄	H ₂	C ₃ H ₈	N ₂				
G20	100	---	---	---	50.72	37.78	0.555	Adjustment gas
G21	87	---	13	---	54.76	45.28	0.684	Substitute gas

Lifting Index $I_l=0.941$

Flashback Index $I_f=1.034$

Yellow tip Index $I_y=0.762$

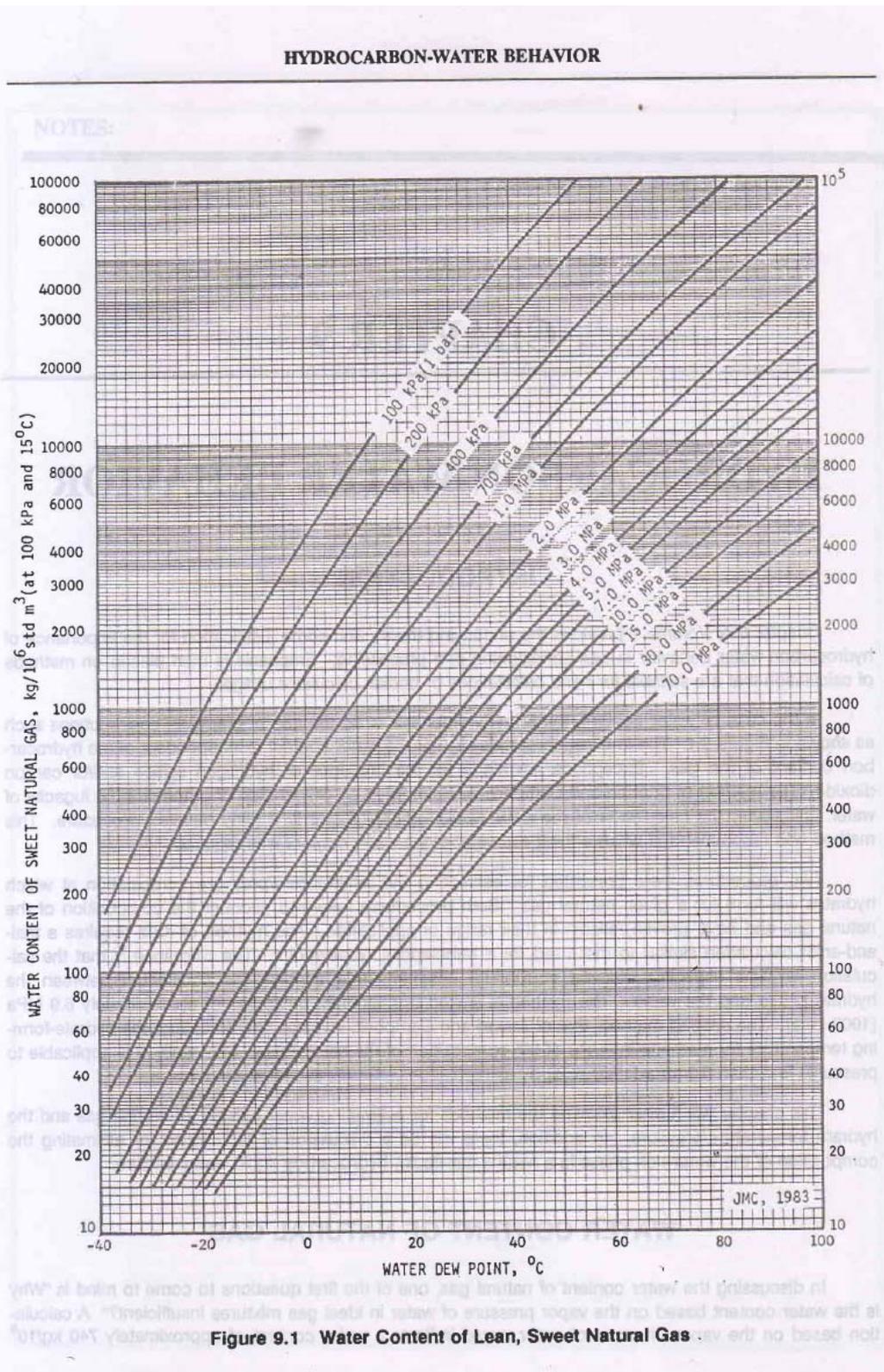
Interchangeability in the A.G.A program is determined by calculating indices for lifting, flash back, and yellow tipping (complete combustion), and by establishing preferable and objectionable limits for each. The equations used for the individual indices were derived experimentally by the Bulletin 36 work. An exactly interchangeable gas, that is, if the adjustment gas and the substitute gas were of the same composition, would yield values of I_l , I_f and I_y equal to 1,0. The preferable limits are pegged at this value. The objectionable limits are values which just provide satisfactory performance. Such Values are determined by testing a variety of appliances, by setting them up on the adjustment gas, and by changing gas mixtures until the three interchangeability criteria occur, namely, lifting, flashback and yellow tipping.

The other methods are used for calculating interchangeability Indices that you can refer to *BS EN ISO 13686*.

ANNEX F
Figures for Water Content of Natural Gas
(Informative)

This Annex provide figures from Gas Conditioning and Processing Handbook (Volume 2, Campbell Petroleum Series) which show the water vapor content saturated at various temperatures and pressures.

ISO 18453 specifies a method to provide users with a reliable mathematical relationship between water content and water dew point when one of the two is known.



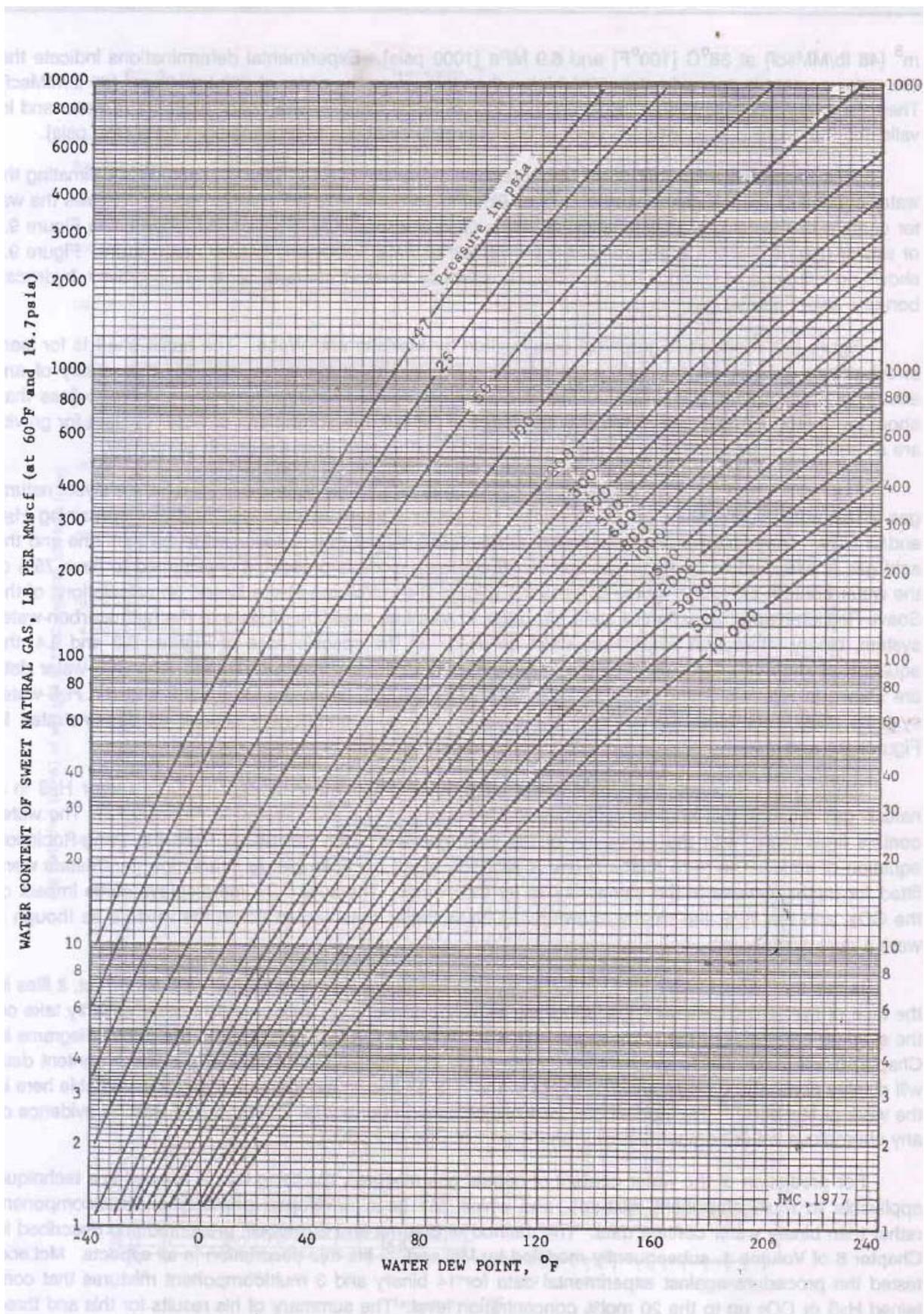


Figure 9.1(a) Water Content of Lean, Sweet Natural Gas

ANNEX G

List of Informative References (Informative)

To provide this standard specification the following references are used:

G.1 STANDARDS

- **BS EN ISO 13686 {2005}** "Natural Gas – Quality Designation"
- **AS 4564 (2011)** "Australian Standard Specification for General Purpose Natural Gas"
- **NZS 5542 (2008)** "New Zealand Specification for Reticulated Natural Gas"
- **Gas Quality Standards in the European Union**
DG Energy and Transport, European Commission
- **Draft Final Report on the Requirements for a Single Natural Gas Quality Standard for Northern Ireland and the Republic of Ireland**
The Commission for Energy Regulation, Northern Ireland Authority for Utility Regulation (CER/09/037)
- **BS EN ISO 6327 (2004)** "Gas Analysis – Determination of the Water Dew Point of Natural Gas – Cooled Surface Condensation Hygrometer"
- **BS EN ISO 6976 (2005)** "Natural Gas - Calculation of Calorific Values, Density, Relative Density and Wobbe Index from Composition"
- **BS EN ISO 12213-1 (2005)** "Natural Gas - Calculation of Compression Factor - Part 1: Introduction and Guidelines"
- **BS EN ISO 13443 (2005)** "Natural Gas - Standard Reference Conditions"
- **ISO 18453 (2004)** "Natural Gas – Correlation between Water Content and Water Dew Point"
- **IGS-PM-105 (0) (1990)** "Dry Gas Filter"

G.2 PUBLICATIONS

- **CAMPBELL, "Gas Conditioning and Processing"**
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