AS 4564:2020

Australian STANDARD®

# General-purpose natural gas

STANDARDS Australia

This Australian Standard® was prepared by AG-010, Natural Gas Quality Specifications. It was approved on behalf of the Council of Standards Australia on 21 May 2020.

This Standard was published on 5 June 2020.

The following are represented on Committee AG-010:

Australian Energy Council
Australian Energy Market Operator
Australian Petroleum Production and Exploration Association
Australian Pipeline And Gas Association
Energy Networks Australia
Gas Appliance Manufacturers Association of Australia
Gas Energy Australia
Gas Technical Regulators Committee
National Energy Resources Australia

This Standard was issued in draft form for comment as DR AS 4564:2019.



ISBN 978 1 76072 861 8

Australian STANDARD®

# General-purpose natural gas

Originated as AS 4564—2003 (AG 864).
Previous edition 2011.
Fourth edition 2020.

# Preface

This Standard was prepared by the Standards Australia Committee AG-010, Natural Gas Quality Specifications, to supersede AS 4564—2011.

The objective of this Standard is to provide purchasers, transporters and users of natural gas with a product that is safe to use and handle, and to provide certainty of quality and performance for designers and manufacturers of appliances, equipment and vehicles which use natural gas.

The major changes in this edition are as follows:

(a) Clarification and simplification to reduce misinterpretation and misapplication.

(b) Inclusion of requirements for odorization when required by an application.

The terms “normative” and “informative” have been used in this Standard to define the application of the appendix to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is only for information and guidance.

# Contents

## Introduction

This Standard sets out the requirements for providing natural gas, suitable for both transportation and general-purpose use and provides the range of gas properties consistent with safe operation of natural gas appliances.

It specifies general-purpose natural gas, with an emphasis on the safety of the gas for use in natural gas appliances and equipment and for use as fuel in natural gas vehicles. It therefore aims to provide certainty for appliance manufacturers who supply the Australian market.

While natural gas conforming to this Standard is suitable for transportation through pipelines, the Committee has noted that fast tearing fracture control required by AS 2885.1 is dependent on gas composition. However, the Committee has not taken pipeline fracture into consideration in determining the gas composition limits. Management of fracture in new and existing gas pipelines remains the responsibility of the pipeline designer and operator.

# Australian Standard®

# General-purpose natural gas

## Section 1 Scope

This Standard sets out requirements for the safe composition, transportation and supply of general-purpose natural gas for use in natural gas appliances and equipment, and for use as fuel in natural gas vehicles.

This Standard applies to natural gas that is —

(a) from petroleum, landfill, biogas, coal seam and other sources that provide gas for direct or blended supply on a commercial basis through supply systems serving general purpose customers; and

(b) transported and supplied to users for use in natural gas appliances and equipment conforming to the relevant Standards, including natural gas-powered vehicles, natural gas compressors and refuelling facilities.

General purpose natural gas is also subject to legislative requirements relating to quality and may be subject to contractual requirements and variations. Such variations are not within the scope of this Standard.

NOTE Appendices A, B and C provide further information and guidance on gas properties, additional issues to be considered in contracts, and test methods used to verify conformance.

Gas conforming to this Standard is safe for use as a general-purpose natural gas but is not necessarily fit for purpose in other applications such as a dedicated supply to an industrial user. The Standard is not intended to apply to natural gas for supply as a process feedstock but may provide a basis for such a specification. General purpose natural gas may not be from a dedicated source and may be formed by blending gas from different supplies.

## Section 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.

NOTE Documents for informative purposes are listed in the Bibliography.

AS ISO 13443, *Natural gas — Standard reference conditions*

ISO 6976, *Natural gas — Calculation of calorific values, density, relative density and Wobbe indices from composition*

## Section 3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

**3.1**
**general-purpose natural gas**
natural gas suitable for transportation in distribution systems and safe for use in natural gas appliances and equipment in Australia

Note 1 to entry: Conformance with this standard does not imply that the gas is suitable for transportation in all transmission systems without additional requirements.

**3.2**
**higher heating value**
**gross heating value**
**superior heating value**
amount of energy, in $MJ/m^3$, released when one cubic metre of dry gas at standard conditions is completely burnt in air with the products of combustion brought to standard conditions, with the water produced by combustion condensed to the liquid state

**3.3**
**inert gas**
material existing predominantly in a gaseous state at standard conditions which does not contribute to the measured heating value of the gas

Note 1 to entry: 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.

EXAMPLE Carbon dioxide, nitrogen, oxygen and noble gases.

**3.4**
**limit**
value beyond which the specified characteristic or concentration of the component is not permitted to vary

**3.5**
**lower explosive limit**
**LEL**
lowest percentage of gas and air in which combustion can be self-sustaining at standard conditions

**3.6**
**maximum allowable operating pressure**
**MAOP**
maximum pressure at which a pipeline may be operated

**3.7**
**may**
indicates the existence of an option

**3.8**
**natural gas**
mixture of gaseous hydrocarbons of the alkane series, primarily methane but possibly also including ethane, propane and higher hydrocarbons in much smaller amounts, used as a fuel. It may also include some inert gases, plus minor amounts of other constituents including odorizing agents

**3.9**
**oil**
mixture of hydrocarbons and other liquids that are non-volatile at atmospheric conditions

Note 1 to entry: 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.

**3.10**
**relative density**
**specific gravity**
density of a gas divided by the density of dry air of reference composition at the same specified conditions of pressure and temperature

[SOURCE: ISO 6976:2016, 3.4]

**3.11**
**shall**
indicates that a statement is mandatory

**3.12**
**should**
indicates a recommendation

**3.13**
**standard conditions**
temperature of 15 °C and an absolute pressure of 101.325 kPa

Note 1 to entry: Standard conditions for natural gas are specified in AS ISO 13443.

**3.14**
**total sulfur**
sulfur from all sources including odorization of the gas

**3.15**
**Wobbe Index**
measure of the amount of heat released by a gas burner with a constant orifice.

Note 1 to entry: It is an indicator of the interchangeability of fuel gases such as natural gas, liquefied petroleum gas (LP Gas), and town gas and is used to compare combustion energy output of a burner.

Note 2 to entry: It is expressed in $MJ/m^3$ and is calculated as —

$$WI = \frac{\text{Heating value}}{\sqrt{\text{Relative density}}}$$

# Section 4 Requirements

## 4.1 Safety

The properties of general-purpose natural gas shall be maintained at all times within the limits set out in Table 4.1.

## 4.2 Odorization

Where odorization is required, the odour shall be as specified in Table 4.1.

Odorants shall be —

(a) suitable for the type of odorizer used;

(b) compatible with the gas; and

(c) appropriate for the general climatic conditions where the gas is distributed and used.

NOTE Odorization may be required by specific jurisdictional legislative requirements.

## 4.3 Contaminants

The gas shall not contain —

(a) 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;

(b) unsaturated or aromatic hydrocarbons to an extent that causes unacceptable sooting; or

(c) other substances to the extent that they cause damage to, or problems in operation of, pipelines or appliances or that cause the products of combustion to be toxic, or hazardous to health, other than substances that are usually found in natural gas combustion products.

## 4.4 Conformance

### 4.4.1 Demonstration of conformance

The values of gas properties shall meet the limits set out in Table 4.1. A range of standardized test methods able to demonstrate conformance are contained in Table C.1.

The values of characteristics or concentrations of components of natural gas shall not lie beyond the limits given in Table 4.1. The values measured or calculated shall be at the level of precision given in the test method used.

In the event of dispute, the procedure described in ISO 4259, which uses precision data in the interpretation of test results, should be used.

NOTE Most of the suggested test methods given in Table C.1 contain a statement of precision, i.e. the repeatability and reproducibility of the method.

**Table 4.1 — Limitations of gas properties**

| Characteristics and components | | Limit |
|---|---|---|
| Wobbe Index | Minimum | 46.0 MJ/m$^3$ |
| | Maximum | 52.0 MJ/m$^3$ |
| Higher heating value | Maximum | 42.3 MJ/m$^3$ |
| Oxygen | Maximum | 0.2 mol % |
| Hydrogen sulfide | Maximum | 5.7 mg/m$^3$ |
| Odour intensity | Minimum | Where required, detectable at a level not exceeding 20 % LEL |
| Total sulfur | Maximum | 50 mg/m$^3$ |
| Water content | Maximum | Dewpoint 0 °C at the highest MAOP in the relevant transmission system (in any case, no more than 112.0 mg/m$^3$) |
| Hydrocarbon dewpoint | Maximum | 2.0 °C at 3500 kPa gauge |
| Total inert gases | Maximum | 7.0 mol % |
| Oil | Maximum | 20 mL/TJ |

The sulfur level upstream of the point(s) of addition of odorant shall be such as to allow for any increase due to the odorant.

NOTE 1 m$^3$ means 1 m$^3$ of dry gas at the standard conditions (see 3.13).

NOTE 2 mol % means the mole faction of gas expressed as a percentage.

NOTE 3 Where odorization is required, the odorant content required to satisfy the detectability at 20 % LEL needs to account for variations in the odorant used and residence time and may be subject to specific jurisdictional requirements.

NOTE 4 Figure A.1 shows the dewpoint at zero degrees Celsius with water content plotted against pressure.

NOTE 5 See Appendix A for further information on characteristics and components of natural gas.

### 4.4.2 Testing

Determination of the value of the properties of the gas shall be at a frequency that ensures conformance at all times.

Test methodologies and equipment shall be selected in consideration of the test conditions, required accuracy and uncertainty of measurement. This Standard does not prescribe particular methods for specific tests; however, it may provide guidance.

Note A selection of standardized test methods is included in Appendix C.

# Appendix A
(informative)

# General-purpose natural gas — background and limitations

## A.1 Background

This Standard encompasses the range of Australian natural gases in general-purpose use at the time of publication.

In order to retain the greatest flexibility of supply no attempt has been made to detail the composition of the gas beyond those compounds normally regarded as gas contaminants and which have a detrimental effect on the properties of the gas.

Specification limits are generally consistent with overseas practice. The limit test gases used for the assessment of gas appliances to Australian standards are specified to match this specification, refer to AS/NZS 3645. In this respect the specification is intended to cover only those gases that are primarily methane. This specification does not cover other gases such as LP Gas/air mixtures and synthetic natural gas.

Requirements relating to limits on particular characteristics and components are contained in Table 4.1. More information on those characteristics and components and on contaminants is provided in this Appendix.

## A.2 Limits

In any natural-gas specification, a balance must be achieved between optimum performance, which requires the narrowest possible combustion limits, and cost of supply, which if possible, requires no limits at all so that any available gas can be used. In an endeavour to resolve this issue, the limits are set as wide as possible while still maintaining safe combustion performance in gas burning appliances certified for use in Australia. If the specification of gas deviates from these limits both safety and performance may be compromised. This is dependent on the duration and extent of the deviation.

Although rate of change of variables within the limits is not addressed in this specification, it may be relevant to the performance of combustion control systems particularly in lean burn and low NOx applications. In addition, rapid changes in Wobbe Index for example may lead to customer complaints, as there may be a noticeable change in performance with some appliances.

## A.3 Characteristics and components

### A.3.1 Relative density

It is expected that for all practical gases available, or likely to be available commercially, relative density values would be in the range of 0.55 to 0.70.

### A.3.2 Wobbe Index

The 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.

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

If a Wobbe Index is too low, it may cause flame abnormality. It may also cause increased carbon monoxide formation in surface combustion burners.

If a Wobbe Index is too high, it may cause high levels of carbon monoxide in the combustion products of conventional appliances. It may also cause overheating.

### A.3.3 Higher heating value

Gases with higher heating values greater than the limit in this standard have an unacceptably higher propensity for incomplete combustion and sooting, which would not necessarily be detected by tests using existing limit gases defined in the appliance Standard.

### A.3.4 Oxygen

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

### A.3.5 Hydrogen sulfide

The limitation on hydrogen sulfide in the gas is necessary because of its corrosive effects. 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 the transportation of gas in steel pipes and for the use of natural gas in vehicles where natural gas is typically stored at pressures up to 26 MPa.

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.

NOTE: Further information on the effects of hydrogen sulfide is contained in AS 2885.1.

### A.3.6 Odour intensity

It is a standard safety performance requirement for odorized natural gas that the odour shall be distinctive (and/or discernible) to a person with a normal sense of smell at the concentration specified in Table 4.1. This will be referenced as odour intensity (or odorosity).

Testing methods may include one of more of the following —

(a) gas chromatography;

(b) olfactory (odorometer);

(c) stain tube; or

(d) electrochemical sensors.

NOTE 1 Some jurisdictions may require a specified method, or a combination of methods, in order to demonstrate conformance.

NOTE 2 Odorant compounds may be retained or react on many surfaces. Where field samples are taken for laboratory analysis, the entire sampling process, including the time permitted between taking the sample and conducting the analysis which should be as short as possible, needs to be validated.

### A.3.7 Total sulfur

The maximum permitted sulfur concentration comprises sulfur from all sources including odorization of the gas. Odorants commonly used in Australia contribute to the sulfur level in the gas. In setting the sulfur limit, the use of flueless heating in Australia has been taken into account.

Sulfur in the gas burns to sulfur dioxide ($SO_2$) which enters the indoor atmosphere when flueless gas appliances are used. $SO_2$ is an irritant gas and is limited under WHO guidelines to a 10 min maximum of 500 μg/m$^3$ and a 24 h average of 20 μg/m$^3$. It is noted that at the appliance standard limit conditions, under which a flueless space heater is required to automatically shut down (0.0075 % CO, 2.0 % $CO_2$, 18 % $O_2$) $SO_2$ concentrations may exceed the WHO guidelines if the total sulfur concentration is at 50 mg/m$^3$ for an extended period.

Elemental sulfur deposition is an operating issue in some transmission systems, see Clause A.3.13. This has occurred in some systems with sulfur concentrations below the specified limit.

### A.3.8 Water

This specification covers water content by nominating the dewpoint at maximum transmission pressures. Additionally, an absolute limit (mg/m$^3$) is stated. Figure A.1 illustrates the water content in mg/m$^3$ producing a dewpoint of 0 °C for a range of transmission pressures.

Liquid phase water can cause corrosion and the formation of gas hydrates 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 applications 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.

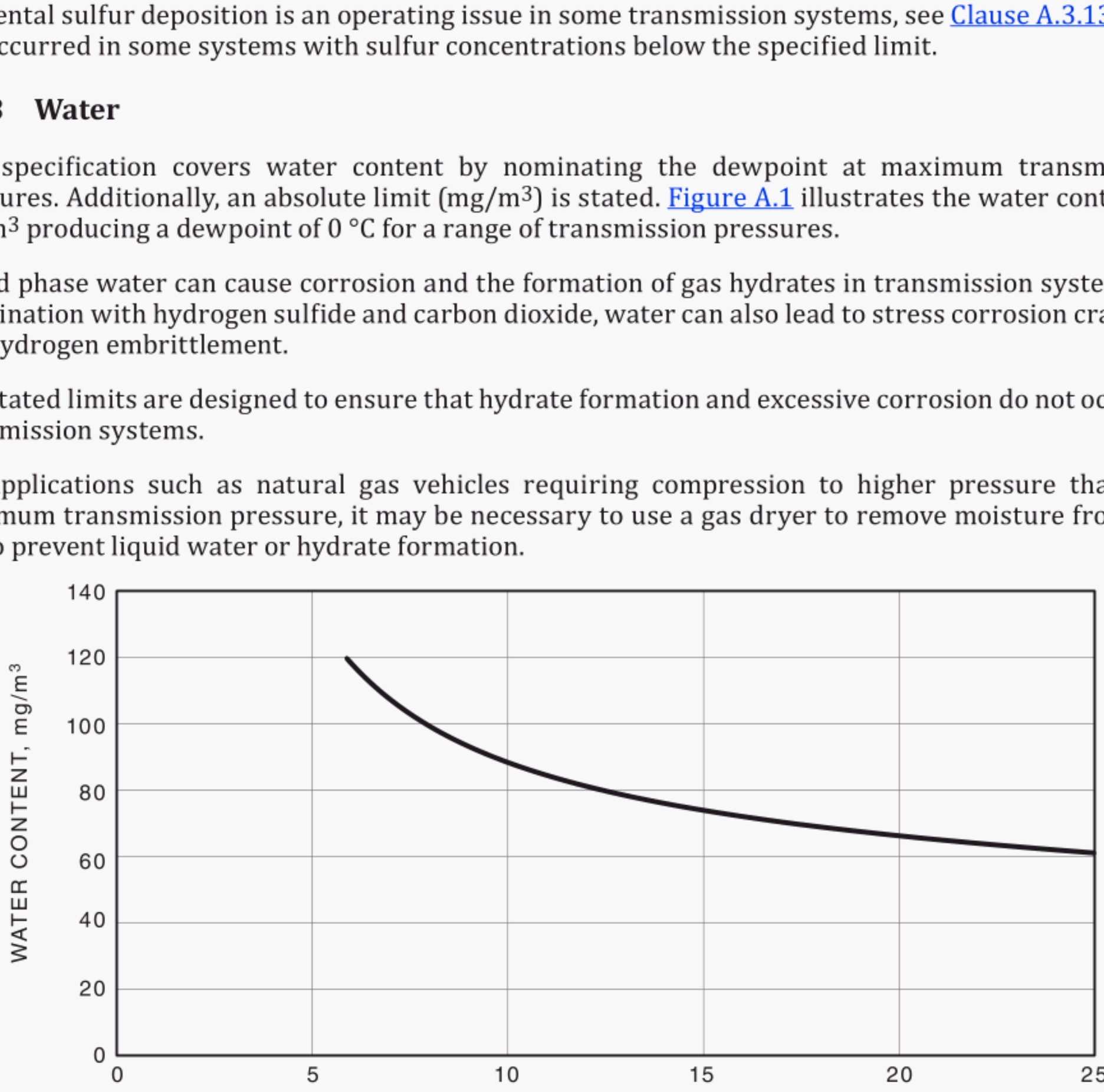


**Figure A.1 — Dewpoint at zero degrees Celsius**

### A.3.9 Hydrocarbon dewpoint

The hydrocarbon dewpoint limit controls the level of heavy hydrocarbons (propane and heavier) in the gas. At high pressures, condensation of heavy hydrocarbons may occur at low temperatures. The pressure and temperature specified do not guarantee the total absence of retrograde condensation.

Additionally, retrograde condensation can occur in transmission systems at pressures lower than the MAOP. It is this phenomenon that effectively determines the maximum allowable limits of heavy hydrocarbons in natural gas. The pressure and temperature specified are designed to limit retrograde condensation for Australian natural gases, refer to ISO 13686.

The specified pressure approximates the cricondentherm pressure which, for Australian natural gases, is usually within the range of 2 MPa to 4 MPa.

### A.3.10 Total inert gases

The specification for total inert gases is intended, in conjunction with the Wobbe Index limits, to limit the levels of higher hydrocarbons. High levels of $CO_2$ in particular could have significant implications for some gas consumers with specific needs.

### A.3.11 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.

### A.3.12 Oil

The limit for oil contamination is based on the *Queensland Petroleum and Gas (Production and Safety) Regulation 2018*, which in turn was based on Australian Pipelines and Gas Association (APGA) "good current practice" for compressor station operation. The limit is an acknowledgement that, while 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. Conformance to Table 4.1 is ascertained by retrospective logging of oil collected from filters or other entrapment elements.

### A.3.13 Other contaminants

The level at which some objectionable constituents might cause damage or be a hazard to health are listed below:

(a) **Elemental Sulfur: 1.0 µg/m³**

Elemental sulfur deposition has caused operational problems in a number of transmission systems. Elemental sulfur vapour concentration should be below 1.0 µg/m³ in order to avoid deposition of elemental sulfur at operating temperatures above 2 °C. The elemental sulfur formation and deposition process is extremely complicated and depends on a number of contributing factors. This limit is based on elemental sulfur/natural gas phase equilibria data published as part of elemental sulfur deposition studies (see Pack, D J).

(b) **Mercury: 1.0 µg/m³**

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

Mercury removal equipment for natural gas is reported as being able to reduce inlet concentrations of 25–50 μg/m$^3$ to 0.1 μg/m$^3$. The atmospheric concentration (depending on location) is generally around 0.02 μg/m$^3$ but higher in some industrial centres.

The mercury level of 1 μg/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.

(c) **Radioactivity: 600 Bq/m$^3$**

Radioactivity in natural gas is due primarily to radon. Radon is a chemically inert gas which produces radiation as it decays via a series of radioactive nuclides to lead 206, which is stable. Of these radioactive nuclides lead 210, which has a 22-year half-life, is of the greatest concern. It follows that the decay products of radon can create heavy-metal dusts which may accumulate in pipelines, vessels, and filters. In systems where natural gas is known to contain radon, protective measures should be taken in dealing with dust accumulations.

The radioactivity in natural gas limit of 600 Bq/m$^3$ is such that the contribution of combustion products to the indoor radiation level will not exceed the recommended exposure monitoring limits set by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) and will not add significantly to the background level in a house or factory from gas combustion.

Testing for radioactivity levels poses a number of problems and currently does not have a standardised test method. Typically this is tested for when a new producer first comes online to demonstrate whether radioactivity poses a hazard.

# Appendix B
(informative)

# Gas transportation and supply considerations

Aspects of gas quality outside the scope of this Standard, which may be considered when establishing parameters for gas transportation and supply, include:

(a) The rate of change of critical parameters.

(b) Frequency of agreed tests.

(c) Exchange of results of all monitoring/testing undertaken.

(d) Retention period for records of the tests carried out.

(e) Variations and their duration outside the absolute limits set out in Table 4.1.

(f) Response actions to be taken relating to variations and emergencies.

(g) Commissioning activities.

EXAMPLE Hydrostatic testing and drying of pipelines and initial odorant injection activities.

# Appendix C
(informative)

# Means of demonstrating conformance

## C.1 Test methods

Table C.1 sets out details of test methods that meet the requirements of this Standard for the analysis of methane-based gases to identify characteristics and components.

NOTE: For further information on sampling of natural gas, refer to ISO 10715.

**Table C.1 — Test methods**

| Characteristics and components | Range | Suggested test method |
|---|---|---|
| Wobbe Index | — | ISO 6974 (all parts)<br>ISO 6975<br>ISO 6976 |
| Higher heating value | — | ISO 6974 (all parts)<br>ISO 6975<br>ISO 6976<br>ASTM D3588 |
| Relative density | — | ISO 6974 (all parts)<br>ISO 6975<br>ISO 6976<br>ASTM D1070<br>ASTM D3588 |
| Oxygen | 0.001 % to 0.5 % | ISO 6974 (all parts) |
| Hydrogen sulfide | 0.1 mg/m$^3$ to 100 mg/m$^3$ | ISO 6326 (all parts) |
| Odour intensity | — | ISO 19739<br>ISO 13734<br>ASTM D6273<br>ASTM D7493<br>NZS 5263 |
| Total sulfur (as S) | 0.5 to 1000 mg/m$^3$ | ISO 6326<br>ISO 19739<br>ASTM D1072<br>ASTM D7165<br>ASTM D7166 |
| Water | 5 mg/m$^3$ to 5 000 mg/m$^3$ if concentration of sulfur compounds in the gas is less than 20 % of the water content | ISO 10101 (all parts) |
| | Calculation of water vapour content based on dewpoint measurement | ISO 6327<br>ASTM D1142 |

**Table C.1** *(continued)*

| Characteristics and components | Range | Suggested test method |
|---|---|---|
| Hydrocarbon dewpoint | −40 °C to +10 °C | ISO 23874<br>ISO/TR 11150 |
| Mercury | | ISO 6978-1<br>ISO 6978-2<br>ASTM D5954<br>ASTM D6350 |
| Elemental Sulfur | | ASTM D6228<br>ASTM D7800 |

No standardised test method is available for the measurement of radioactivity in natural gas.

## C.2 Precision of measurement

Conformance to this Standard may be demonstrated by measurement or calculation, at the accepted levels of precision in the selected methods, of the value of a characteristic or component as within the specified limit.

NOTE For further information on assessing accuracy of measurement methods, refer to ISO 5725-1.

# Bibliography

AS 2885.1, *Pipelines—Gas and liquid petroleum, Part 1: Design and construction*

AS/NZS 3645, *Essential requirements for gas equipment*

ISO 4259, *Petroleum products — Determination and application of precision data in relation to methods of test*

ISO 5725-1, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

ISO 6326, *Natural gas — Determination of sulfur compounds* (all parts)

ISO 6327, *Gas analysis — Determination of the water dew point of natural gas — Cooled surface condensation hygrometers*

ISO 6974 (all parts), *Natural gas—Determination of composition and associated uncertainty by gas chromatography*

ISO 6975, *Natural gas — Extended analysis — Gas-chromatographic method*

ISO 6978-1, *Natural gas — Determination of mercury — Part 1: Sampling of mercury by chemisorption on iodine*

ISO 6978-2, *Natural gas — Determination of mercury — Part 2: Sampling of mercury by amalgamation on gold/platinum alloy*

ISO 10101, *Natural gas — Determination of water by the Karl Fischer method*

ISO 10715, *Natural gas — Sampling guidelines*

ISO 13686, *Natural gas — Quality designation*

ISO 13734, *Natural gas — Organic components used as odorants — Requirements and test methods*

ISO 19739, *Natural gas — Determination of sulfur compounds using gas chromatography*

ISO 23874, *Natural gas — Gas chromatographic requirements for hydrocarbon dewpoint calculation*

ISO/TR 11150, *Natural gas - Hydrocarbon dew point and hydrocarbon content*

ASTM D1070, *Standard test methods for relative density of gaseous fuels*

ASTM D1072, *Standard test method for total sulfur in fuel gases by combustion and barium chloride titration*

ASTM D1142, *Standard test method for water vapor content of gaseous fuels by measurement of dew-point temperature*

ASTM D3588, *Standard practice for calculating heat value, compressibility factor, and relative density of gaseous fuels*

ASTM D5954, *Standard test method for mercury sampling and measurement in natural gas by atomic absorption spectroscopy*

ASTM D6228, *Standard test method for determination of sulfur compounds in natural gas and gaseous fuels by gas chromatography and flame photometric detection*

ASTM D6273, *Standard test method for natural gas odor intensity*

ASTM D6350, *Standard test method for mercury sampling and analysis in natural gas by atomic fluorescence spectroscopy*

ASTM D7165, *Standard practice for gas chromatograph based on-line/at-line analysis for sulfur content of gaseous fuel*

ASTM D7166, *Standard practice for total sulfur analyzer based on-line/at-line for sulfur content of gaseous fuels*

ASTM D7493, *Standard test method for online measurement of sulfur compounds in natural gas and gaseous fuels by gas chromatograph and electrochemical detection*

ASTM D7800, *Standard test method for determination of elemental sulfur in natural gas*

NZS 5263, *Gas detection and odorization*

Pack, D. J. *Elemental sulphur formation in natural gas transmission pipelines*. PhD thesis. University of Western Australia, Australia. 2005. Available at https://research-repository.uwa.edu.au/en/publications/elemental-sulphur-formation-in-natural-gas-transmission-pipelines-2

**Further reading**

Specialist text should be consulted for detailed discussion of natural gas characteristics in this Standard; some are listed below.

AS 2649, *Petroleum liquids and liquefied petroleum gases—Measurement—Standard reference conditions*

AS 5092, *CNG refuelling stations*

AS/NZS 2739, *Natural gas (NG) fuel systems for vehicle engines*

AS/NZS 4645.1, *Gas distribution networks, Part 1: Network management*

NZS 5425, *Code of practice for CNG compressor and refuelling stations*

NZS 5442, *Specification for reticulated natural gas*

ISO 15403, *Natural gas—Natural gas as a compressed fuel for vehicles (all parts)*

ISO/TR 16922, *Natural gas — Odorization*

AEMO. *Gas Quality Guidelines.* Available at https://www.aemo.com.au

AEMO. *Gas Quality Standard and Monitoring Guidelines (Declared Transmission System)*. Available at https://www.aemo.com.au

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ISBN 978 1 76072 861 8