GAS QUALITY STANDARD AND MONITORING GUIDELINES (DECLARED TRANSMISSION SYSTEM)

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VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
1.0		Refer to “Gas Quality Standard – System Injection Points” for earlier history.
2.0	29 May 2014	Updated to reflect changes in AS 4564-2011.
3.0	6 October 2016	Updated to include requirements for developing gas quality monitoring systems and gas quality monitoring plans. Title updated.

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Important Notice

Purpose

AEMO has prepared this document to provide information about gas quality standards, and gas quality monitoring for system injection points in the Victorian declared transmission system, as at the date of publication.

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1. INTRODUCTION

1.1. Purpose and Scope

This Guide provides information about the gas quality standard applicable to all system injection points in the Victorian Declared Transmission System (referred to as 'standard gas quality specifications' under Part 19 of the National Gas Rules; see also AS 4564-2011, and Gas Safety (Gas Quality) Regulations[1]).

It also provides an overview of AEMO's requirements for gas quality monitoring systems and plans (per rule 288 of the National Gas Rules) for the Victorian Declared Transmission System (DTS).

1.2. Definitions and Interpretation

1.2.1. Glossary

The words, phrases and abbreviations set out below have the meanings set out opposite them when used in this Guide.

Terms defined in the National Gas Law or the National Gas Rules have the same meanings in this Guide unless otherwise specified in this clause.

Term	Definition
Becquerel (Bq)	Number of nucleus decays per second in a given quantity of radioactive substance.
CTM	Custody Transfer Meter.
DTS	Declared Transmission System in Victoria.
ESV	Energy Safe Victoria.
Max	Maximum.
Microgram (µg)	A unit of mass equal to one millionth (10^{-6}) of a gram.
Milligram (mg)	A unit of mass equal to one thousandth (10^{-3}) of a gram.
Min	Minimum.
Responsible Person	As defined by rule 292 of the Rules.
RTU	Remote Telemetry Unit.
Rules	National Gas Rules.
TBM	Tertiary Butyl Mercaptan - a Mercaptan used in gas odorisation.
THT	Tetrahydrothiophene - a cyclic sulphide used in gas odorisation.

1.2.2. Interpretation

The following principles of interpretation apply to this Guide unless otherwise expressly stated:

(a) This Guide is subject to the principles of interpretation set out in Schedule 2 of the National Gas Law.

(b) References to time are references to Australian Eastern Standard Time.

[1] Gas Safety (Gas Quality) Regulations 2007. Version No. 003. Version as at 12 February 2016.

1.3. Related Documents

Reference	Title	Location
AS 2885	AS 2885-2008 - Pipelines - gas and liquid petroleum	Online
AS 4564	AS 4564-2011 - Specification for general purpose natural gas	Online
Regulations	Gas Safety (Gas Quality) Regulations 2007	Online
Gas Quality Guidelines	AEMO Gas Quality Guidelines	AEMO website
NGR	National Gas Rules	AEMC website

2. GAS QUALITY STANDARDS

2.1. Substantive Provisions

The gas quality standard shown in Table 1 sets out the quality standard with which gas injected into or withdrawn from the DTS must comply. This is to be read in conjunction with section 2.2 below and the Gas Safety (Gas Quality) Regulations. The units in the table are as follows:

- Cubic metre (m^3) refers to a cubic metre of gas at standard conditions of 101.325 kPa absolute and 15°C.
- Pressures are gauge unless otherwise specified.

Table 1 — Gas Quality Standard

Parameter/Characteristic	Gas Quality Standard Limit
Required under regulation 6 of the Regulations / AS-4564	
Wobbe Index – Max	52.0 MJ/m^3
Wobbe Index – Min	46.0 MJ/m^3
Higher Heating Value – Max	42.3 MJ/m^3
Oxygen – Max	0.2 mol%
Hydrogen Sulphide – Max	5.7 mg/m^3
Total Sulphur – Max (including odorant)	50 mg/m^3
Water Dewpoint at Maximum Transmission Pressure – Max	0 °C
Water content of gas – Max (based on 15,000 kPa)	73 mg/m^3
Hydrocarbon Dewpoint – Max	2.0 °C at 3500 kPa
Total Inerts – Max (including Oxygen)	7.0 mol%
Oil – Max	20 mL/TJ
Gas Odorisation	Odorisation at rates between 7.0 and 14.0 mg/m^3 of a 70/30 blend of THT/TBM.
Elemental Sulphur – Max	1.0 µg/m^3
Mercury – Max	1.0 µg/m^3
Radioactivity – Max	600 Bq/m^3
Objectionable Constituents	Not to cause damage, interfere, or harm to persons.[2]
Additional requirements	
Mercaptan Sulphur – Max	5.0 mg/m^3
Temperature – Max	50 °C
Temperature – Min	2 °C

[2] See section 2.2 AS 4564 - 2011 - Specification for general purpose natural gas. Version as at 12 February 2016.

2.2. Explanatory Schedule

This section explains the specification limits set out in section 2.1.

2.2.1. Water content

For the purposes of gas injected at a system injection point, the relevant transmission pressure for determining water dew point is deemed to be 15,000 kPa. For typical natural gas compositions, a 0°C dewpoint at 15,000 kPa corresponds to a water content of 73 mg/m^3, and AEMO uses this as the basis for the specification in this document.

2.2.2. Compressor oil

The limit of 20 mL/TJ is based on AS 4564, which was derived from the Queensland Petroleum and Gas (Production and Safety) Regulation 2004. The limit is an acknowledgment that, while undesirable, it is almost inevitable that some lubricating oil will escape from filters and coalescers downstream from compressors and other facilities. The limit is intended to restrict oil accumulation to manageable quantities and provide guidance for the design of oil separation equipment at compression facilities.

2.2.3. Objectionable constituents

The prescribed standard of quality for natural gas[3] conveyed through a transmission or distribution pipeline is set out in AS 4564 as follows:

"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 interference 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 which causes unacceptable sooting;

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".

The levels at which some objectionable constituents might cause damage or be a health hazard are:

Elemental Sulphur: 1.0 µg/m^3

Elemental sulphur vapour concentration should be below 1.0 µg/m^3 (approx. 1x10^{-4} ppm) to ensure that there will be no deposition of elemental sulphur at operating temperatures above 2°C. The elemental sulphur formation and deposition process is extremely complicated and depends on a number of contributing factors. The limit is based on elemental sulphur equilibrium data published as part of elemental sulphur deposition studies by Dr. D. Pack (Curtin University)[4].

Mercury: 1.0 µg/m^3

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.

The National Occupational Health & Safety Commission (NOHSC) time weighted average (8 hours a day for five days a week) occupational health exposure is 25 µg/m^3 in air.

[3] Regulation 6 of the Gas Safety (Gas Quality) Regulations 2007. Version No. 003. Version as at 12 February 2016.
[4] Elemental Sulphur Formation in Natural Gas Transmission Pipelines. 2005. Version as at 12 February 2016.

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

The figure of 1.0 µg/m^3 mercury in natural gas will not add significantly to the background mercury level in a house or factory, is technically feasible and well below the occupational health exposure level after dilution during combustion.

Radioactivity: 600 Bq/m^3

Radioactivity historically was not considered to be not an issue in Victoria. However as radon has since been detected in Victoria, testing is to be conducted for new fields and as needed to monitor compliance with AS 4564 for existing fields. The limits in AS 4564 are based on Western Australian practice and provide guidance for the development of future gas sources and interstate gas transfers.

Radioactivity in natural gas is due primarily to radon. The limit of 600 Bq/m^3 is such that the contribution of combustion products to the indoor radiation level will not exceed the exposure monitoring limit set by the Australian Radiation Protection and Nuclear Safety Agency of 200 Bq/m^3. At these levels, gas combustion will not add significantly to the background radiation levels in a house or factory. The average concentration of radon in Australian homes is about 12 Bq/m^3.

2.2.4. Gas odorisation

Regulation 7 of the Gas Safety (Gas Quality) Regulations provides that for the purposes of sections 33(1) and (2) and 79A(1) of the Gas Safety Act 1997, it is a prescribed standard of quality that all gas must:

"a) have an odour which is distinctive and unpleasant; and

b) have an odour level that is discernible at one-fifth of the lower explosive limit of the gas".

AEMO's preferred gas odorant is a blend of 70% THT and 30% TBM injected into the gas stream at a rate of at least 7 mg/m^3 in the gas. This is to ensure that gas withdrawn from the DTS has an odorant concentration of at least 7 mg/m^3 in the gas. This gas odorisation regime continues to be considered adequate to meet Gas Safety (Gas Quality) Regulation requirements. This mix is used as the odour is familiar to the community. Other odorant blends and injection rates are acceptable if they also meet the Gas Safety (Gas Quality) Regulation requirements.

While odorant injection rates from 7 to 14 mg/m^3 of gas are acceptable, rates of up to 23 mg/m^3 (usually limited-term associated with "conditioning" new pipelines) are acceptable, provided the injection does not create "nuisance" leak reporting**.**

2.2.5. Mercaptan sulphur

This mercaptan sulphur level relates to the smell of gas before odorant is added. It is based on the level likely to impact on odorisation levels.

Mercaptan sulphur is continuously measured only if initial measurements indicate that significant levels of mercaptan sulphur are present in the gas-producing geological formations.

2.2.6. Temperature – minimum

The minimum temperature limit is based on the maximum hydrocarbon dewpoint limit temperature.

2.2.7. Temperature – maximum

The maximum temperature limit is based on the physical limitation of the pipeline. Prolonged operation at high gas temperatures can have a harmful effect on pipeline steels (stress cracking), valve and regulator seals and components, and corrosion protection coatings.

3. GAS QUALITY MONITORING SYSTEM

Gas quality monitoring systems are required at each system injection point and at other points in the DTS as considered necessary or desirable by AEMO under rule 288(1).

Their purpose is to monitor the quality of gas injected into and withdrawn from the DTS. The gas quality monitoring systems are provided and paid for by the DTS service provider, unless otherwise agreed with the connected party associated with that monitoring point.

Rule 288(2) requires AEMO to approve all gas quality monitoring systems connected to the DTS.

3.1. Required Equipment

As outlined in rule 288(4), a gas quality monitoring system must contain the following equipment:

- Gas chromatograph for composition, heating value, relative density, hydrocarbon dewpoint and Wobbe Index.
- Oxygen analyser.
- Sulphur analyser for hydrogen-sulphide and total sulphur.
- Water analyser.

The gas quality monitoring system must also have the following:

- Flow meter.
- Pressure and temperature indication.
- Odorant injection skid.

The odorant skid must include odorant flow indication in addition to the odorant concentration based on pump stroke rate. This is because odorant concentration based on pump stroke can provide a false odorant concentration if there is an issue with the injection skid that results in no odorant being injected into the gas (i.e. blockage or low tank level).

Where multiple measurement instruments of a given type are installed at a particular site, the Responsible Person must nominate which instrument is to be used as the official data source. Where instruments may be swapped-over, a separate official data source must be created with the official instrument data fed through it, thus ensuring that AEMO is able to monitor the correct instrument at all times.

3.2. Communication Requirements

To ensure continuous transmission of gas quality data to AEMO in real time as required by rule 288(3), a primary and secondary (back-up) form of communication is required for all gas quality monitoring systems.

The communications protocol is the same as that used for Custody Transfer Meters (CTM) as defined in the AEMO ‘Wholesale Market Metering Communication Procedures (Victoria)’.

3.3. Data Requirements

Instantaneous readings and hourly average readings of measured parameters are to be made available to AEMO. Hourly average readings are to be retrievable by AEMO from the Remote Telemetry Unit (RTU) at the monitoring point for at least 35 days from when measurements were made.

Data requirements are the same as that used for CTMs as defined in the AEMO ‘Wholesale Market Metering Communication Procedures (Victoria)’.

3.3.1. Time Stamping of Data

Australian Eastern Standard Time (AEST) is to be used in all data transfers for all time stamping.

All readings require a Julian time "time stamp" as outlined below:

- For averaged data, the time stamp relates to the start time of the measurement period. For example, "hourly average" data for the 0900 to 1000 hour period would be time stamped 9:00:00 am.
- "Daily average" readings are to be referenced to 6:00:00 am AEST for the start of the gas day.
- For "instantaneous" (i.e. single measurement) readings, the time stamp relates to the time of measurement.

Time stamping of data must be within ±5 seconds of AEST.

3.3.2. Measurement Range and Frequency

The measurement equipment shall be capable of measuring the required parameters within the required uncertainty for values considered "in specification" as well as values considered "out of specification" up until at least the "curtail" limit for that parameter. These limits can be found in AEMO's "Gas Quality Guidelines".

If the installed equipment cannot cover the specified range, the "curtail" limit for that injection point will be reduced to the measuring limit of the equipment.

The Gas Safety (Gas Quality) Regulations require that the instruments for Wobbe Index and Hydrogen Sulphide (or an instrument that is approved by Energy Safe Victoria (ESV)) determine results at least once every five minutes. All other instruments should determine results at the same frequency of at least every five minutes where practicable.

3.3.3. Measurement Uncertainty and Calibration

To demonstrate compliance with AS 4564 it is necessary to show, at the accepted levels of precision of the test and calculation methods, that the value of a characteristic or concentration of a component is not beyond the specified limit. To meet this requirement, the measurement methods and equipment shall have acceptable and sufficiently low uncertainty and that is traceable to certified Standards.

For transmission pipelines, the Gas Safety (Gas Quality) Regulations require that Wobbe Index and hydrogen sulphide testing be carried out in accordance with methods accredited by NATA, or approved by ESV.

For calibration, the uncertainty of reference standards used to calibrate the monitoring instruments must be sufficient to ensure the reliable determination of the measured parameter. The preparation of reference standards shall be traceable to national standards and shall have acceptable certification.

AEMO's requirements are listed in Table 2 and Table 3 covering online and offline uncertainty requirements respectively.

Table 2 Required Measurement Uncertainties for Online Measurement

Parameter	Uncertainty	Comments
Composition	± 0.05% (repeatability)	Based on HV calculation.
Wobbe Index	± 0.04 MJ/m^3	
Heating Value	± 0.04 MJ/m^3	
Relative Density	± 0.1% of reading	
Hydrogen Sulphide	± 0.5 mg/m^3	
Total Sulphur	± 2.0 mg/m^3	
Mercaptan Sulphur	± 2.0% (repeatability)	Only where required.
Oxygen	± 0.01 mole%	
Water content	± 3.0 mg/m^3	
Total Inert gases	± 0.07 mole%	
Hydrocarbon Dewpoint	± 1.0 °C	
Temperature	± 0.3 °C	
Odorisation	± 0.2 mg/m^3	Calculated or measured.
Mercury	To be determined	Only where required.

Table 3 Required Measurement Uncertainties for Offline Sampling

Parameter	Uncertainty	Comments
Radioactivity	± 50 Bq/m^3	Limit increased from ±10 following feedback that this was not achievable.
Oil	See comments	Retrospective logging of oil collected. Reasonable levels of accuracy are to be used during the measurement and calculation process.
Mercury	See comments.	Reasonable levels of accuracy are to be used during the measurement and calculation process which is to be provided in the Gas Quality Monitoring Plan.
Elemental Sulphur	See comments	Reasonable levels of accuracy are to be used during the measurement and calculation process which is to be provided in the Gas Quality Monitoring Plan.
Objectionable Constituents	See comments	Reasonable levels of accuracy are to be used during the measurement and calculation process.

4. GAS QUALITY MONITORING PLAN

In addition to the gas quality monitoring system requirements outlined in chapter 3, a Gas Quality Monitoring Plan must be submitted to AEMO for approval. This plan is to ensure that the accuracy and reliability of the gas quality monitoring system is implemented and maintained as per rule 288(6). The plan must include:

- Provision for periodic testing, including objectionable contaminants.
- Calibration of the gas quality monitoring system.
- Procedures for ensuring that the gas quality monitoring system including its data will remain free from interference.
- Provision for storing all data relating to operation and calibration of gas quality monitoring equipment, including offline testing.

AS 4564 sets out that the testing of gas quality parameters shall be at a frequency that reasonably confirms compliance at all times.

The sections below details AEMO requirements for inclusion in the Gas Quality Monitoring Plan.

4.1. Frequency of review and change management

Gas Quality Monitoring Plans should be updated and re-submitted to AEMO at an interval of not more than every three years. A yearly confirmation may also be requested by AEMO to confirm that there have been no material changes and the current plan is still appropriate.

In addition, when material changes are made that impact either the gas being monitored or the monitoring systems, AEMO must be notified and an updated Gas Quality Monitoring Plan submitted. These changes may include:

- New fields being brought online.
- Changes to the type of plant processing equipment used.
- Changes in sample point location or measuring equipment.

Changes not requiring an update would be like-for-like equipment changes and equipment repair. These latter changes should be recorded as part of the equipment maintenance records and made available to AEMO on request.

4.2. Site and system overview

The Gas Quality Monitoring Plan should include an overview of the system injection point which includes:

- A schematic diagram of the site showing source(s) of the gas, refer to Appendix A.
- Locations (e.g. geographical location, relation to production facility, pipeline connection, etc.).
- A list of gas quality parameters measured at each location (e.g. if some gas quality parameters are measured at an upstream point).
- Any back-up or stand-by measurement equipment (including data communication pathways).
- Other potential sources of gas quality information (e.g. upstream measurements, adjacent upstream facilities etc.).
- Details of any measurements that are not made (e.g. ESV exemptions, intrinsic nature of the gas, prior measurements, etc.). Copies of any exemptions and other supporting evidence should be attached to the monitoring plan.

- Site and data security (e.g. chain-wire mesh enclosure, manned site, locked room, restricted access to servers etc.).

4.3. Gas quality parameters

Gas quality parameters that need to be included are covered in the table below and the following sections. These parameters are split into two main categories: online and offline monitoring.

Table 4 Gas Quality Parameters

Parameter	Online	Offline	Comments
Composition	✓		Not a "quality" parameter but required for Heating Value, Wobbe Index and corrected volume calculations.
Wobbe Index	✓		
Heating Value	✓		
Relative Density	✓		Not a "quality" parameter but is used for Wobbe Index calculation.
Hydrogen Sulphide	✓		
Total Sulphur	✓		Includes contribution from odorant.
Mercaptan Sulphur	✓		Only where required.
Oxygen	✓		
Water content	✓		
Total Inert gases	✓		
Oil		✓	
Hydrocarbon Dewpoint	✓		
Temperature	✓		
Radioactivity		✓	
Odorisation	✓		Verification of odorant flow (via a Coriolis meter) is required in addition to the flow calculation based on pump stroke rate.
Elemental Sulphur		✓	
Mercury	✓	✓	Online or offline tests are acceptable.
Other objectionable constituants		✓	Where particular objectionable constituents are controlled, this should also be described.

4.3.1. Online requirements for individual gas quality parameters

For each online gas quality parameter, the items that need to be covered include:

- Type of equipment (measurement principle) (e.g. GC, tuned laser, chilled surface, capacitance, etc.).
- Basis of any calculated results (e.g. for hydrocarbon dewpoint: the equation of state and any "characterisation" applied). For the odorisation rate, this needs to state whether it is based on pump stroke or odorant flow, the algorithm applied (if applicable) and any smoothing applied.
- Make and model of equipment including any fitted options and modifications made.
- Measuring range and expected uncertainty over that range.
- Sampling frequency (if not continuous), reading update frequency and any averaging of output.
- Sample point location (e.g. adjacent to meter, upstream of pressure reduction, downstream of filter etc.) and sample lag time.

- Any sample conditioning (e.g. heating, filters, liquids removal, drying, etc.).
- Calibration frequency and duration (e.g. calibration gas applied for 10 minutes every 48 hours or three samples every 24 hours, etc.).
- Calibration principle, frequency and source of calibration material (note that the Gas Quality Regulations require some parameters to be tested using methods accredited by NATA or approved by ESV). Calibration gases must be traceable to national standards. AEMO may request to witness a calibration as agreed with each site.
- Maintenance, repairs and service records for online measurement equipment.
- Any routine “spot tests” to check systems (e.g. chilled mirror tests for hydrocarbon dewpoint or water content or application of a different calibration sample).
- Detection and reporting of equipment faults (e.g. monitoring of equipment by the provider of the system, odorant flow indication or low odorant levels).
- Back-up equipment or other offline alternatives.
- Prevention and/or detection of tampering and/or inadvertent interference with the equipment. (This may be just the site security or may involve locked cabinets, passwords, etc.).
- Alternate sources of gas quality data in the event of equipment failure (e.g. measurements from adjacent facilities or within the facility).
- Details of the electronic storage of data by the provider of the monitoring system and the availability of that data to AEMO (e.g. csv or spreadsheet files, operator screen printouts, etc.).
- Storage of maintenance and measurement system check records, and availability of that information to AEMO (e.g. calibration reports, calibration gas composition certificates, etc.).

4.3.2. Offline requirements for individual gas quality parameters

For each offline gas quality parameter, the items that need to be covered include:

- Initial levels of the component/s from the reservoir or field testing.
- Sampling frequency will be on a risk-based approach in line with the AS 2885.1. The frequency will depend on the parameter and its concentration. Initial timing to use as a guide:
    - Where treating is required to bring the parameter to within specification, sampling should be monthly (higher for establishment).
    - No treatment is required or negligible levels, sampling should be 6 monthly.
- The test method and measurement principle (e.g. GC, tuned laser, chilled surface, capacitance, etc.).
- The basis of any calculated results (e.g. for hydrocarbon dewpoint: the equation of state and any “characterisation” applied, for odorisation: the algorithm applied and any “smoothing”, etc.).
- Measuring range and expected uncertainty over that range.
- Sample point location (e.g. adjacent to meter, upstream of pressure reduction, downstream of filter, etc.) and sample lag time.
- Any sample conditioning (e.g. heating, filters, liquids removal, drying, etc.).
- Calibration frequency.
- Calibration principle and source of calibration material (note that the Gas Quality (Gas Safety) Regulations require some parameters to be tested using methods accredited by NATA or approved by ESV).
- Calibration gases must be traceable to national standards.

- Maintenance, repair and servicing records for offline measurement equipment.
- Storage of maintenance and measurement system check records, and the availability of that information to AEMO (e.g. calibration reports, calibration gas composition certificates, etc.).

Appendix A Schematic Diagram Requirements

A single page schematic with colour coded symbols as outlined in Table 5 is required for each gas quality monitoring system. The schematic needs to show the source(s) of the gas, configuration of the site and location of all gas quality monitoring related equipment (e.g. connected pipelines, storage or production facility(s), gas quality sample points (GC, sulphur, water, O_2) odorant injection, flow meters, line valves, heaters and gas flow direction indication).

Table 5 Schematic Symbols

Parameter	Comments
	GC Sample Point
	Water Analyser Sample Point
	Sulphur Analyser Sample Point
	Oxygen Analyser Sample Point
	Odorant Injection
	Valve
	Flow Meter
	Heater