

GAS QUALITY GUIDELINES

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Important Notice

Purpose

AEMO has prepared this document to provide general information about how AEMO will respond to short-term gas quality excursions outside the standard gas quality specifications (as set out in the National Gas Rules), and AEMO's operational protocols for managing gas quality at system injection points in the Declared Transmission System, as at the date of publication.

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VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
8	16 June 2010	Rebranded.
9	1 April 2014	Updated in accordance with AS 4564-2011.
10	1 September 2017	New template. Key changes include revised excursion timing at the Notify limit, updates to odorant and the addition of contaminant limits.

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CHAPTER 1. INTRODUCTION

1.1. Purpose and Scope

This document provides general information about gas quality and how AEMO will respond to short-term gas quality excursions outside the standard gas quality specifications.

The gas quality specifications are set out in the National Gas Rules (see also AS 4564-2011 and Gas Safety (Gas Quality) Regulations¹) and AEMO's "Gas Quality Standard and Monitoring Guidelines".

This document also covers the technical issues associated with gas quality parameters and AEMO's operational protocols for managing gas quality at system injection points in the Declared Transmission System (DTS).

The Guidelines seek a critical balance between risks to public safety by supply of off-specification gas, and risks to public safety associated with curtailment of the injection, subsequent system disruption and re-lights in gas consumer premises. See also the following provisions of the Gas Safety Act²:

- section 32(c) – a 'gas company' must manage and operate each of its facilities to minimise, as far as 'practicable', the hazards and risks to the safety of the public and customers arising from interruptions to the supply of gas and the reinstatement of an interrupted gas supply; and
- section 33 - a 'gas company' must ensure that, as far as 'practicable', the gas which it conveys meets the prescribed standards of 'quality'.

Under rule 289(5), AEMO may accept the injection of off-specification gas, such as where, in AEMO's reasonable opinion, acceptance is necessary to ensure safety, security or reliability of the DTS (and the Participant has accurately notified AEMO of relevant information under rule 289(4)). However, AEMO may also refuse off-specification gas under rule 289(2), for such a period as AEMO may determine.

Where off-specification conditions become protracted, extreme and/or frequent, or otherwise represent a situation not adequately covered by these Guidelines, AEMO management (in consultation with Energy Safe Victoria) may implement different risk management strategies. For example, in the event that repeated excursions may compromise gas safety, potential curtailment actions will be evaluated on the level of impact and risk involved.

In the event of off-specification gas flows, injections may be rescheduled to minimise the overall risk by reducing the quantity of off-specification gas injected.

These Guidelines do not cover mitigation of the effects of gas quality within the gas quality specification range.

¹ Gas Safety (Gas Quality) Regulations 2007 (VIC). Version No. 003. Version as at 1 May 2017.

² Gas Safety Act 1997 (VIC). Version as at 1 May 2017.

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 these Guidelines unless otherwise specified in this clause.

Italicised terms refer to terms as defined in the National Gas Rules.

Term	Definition
AGA	Australian Gas Association
Bq	Becquerel
CNG	Compressed natural gas
DTS	Declared Transmission System
ESV	Energy Safe Victoria
Facility Operator	Producer, storage provider or interconnected transmission pipeline service provider which are injecting facilities.
HHV	Higher heating value
Participant	A participant registered in a registrable capacity under rule 135A including the description: declared transmission system service provider, Distributor, Producer, Storage Provider, interconnected transmission pipeline service provider, Transmission Customer, Distribution Customer, Retailer and Trader.
NGV	Natural gas vehicles
TBM	Tertiary butyl mercaptan
THT	Tetrahydrothiophene
TPO	Transmission pipeline owner

1.2.2. Interpretation

The following principles of interpretation apply to these Guidelines unless otherwise expressly indicated:

- a) These Guidelines are 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.

1.3. Related Documents

Reference	Title	Location
AS 2885.1	AS 2885.1 2007 – Pipelines – Gas and Liquid Petroleum. Part 1: Design and construction. Appendix P “Environment-Related Cracking”.	Online
AS 4564	AS 4564-2011 – “Specification for general purpose natural gas”.	Online
AS 4838	AS 4838:2002/ISO 11439:2000 “Gas cylinders – High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles.”	Online
ASTM D 1142	ASTM D 1142-95 – “Standard Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew Point Temperature”.	Online
	Bergman D. F., Tek M. R. & Katz D. L. 1975 – “Retrograde Condensation in Natural Gas Pipelines”. American Gas Association.	
	Church B.J. & Winckles G.D. 1999 – “High Wobbe Index gas” – A report on the 5th Draft report prepared on behalf of OGS in Victoria.	
	Gas & Fuel Corporation – “Natural Gas Data” (Various editions).	
	Gas & Fuel Corporation, 1991 – Engineering Policy EP.DD.4005 – “Policy on design temperatures for system components”.	
Regulations	Gas Safety (Gas Quality) Regulations 2007 – Victoria.	Online
	Huffaker R. W. 1995 – “Results of Gas Integration Project Gas Quality Task Force” – Natural Gas Quality & Energy Measurement Practices and Applications, February 5-7, 1996, Clearwater Florida, IGT.	
ISO 13686	ISO 13686 – International Organisation for Standardisation 1998 – “Natural Gas - Quality Designation.”	Online
ISO 6976	ISO 6976 – International Organisation for Standardisation 1995 (Corrected and reprinted 1996) – “Natural Gas – Calculation of calorific values, density, relative density and Wobbe index from composition.”	Online
ISO/TS 16922	ISO/TS 16922:2002 Natural Gas – Guidelines for odorising gases.	Online
NACE MR0175/ISO 15156	NACE MR0175/ISO 15156-2-2003 – Petroleum and natural gas industries – Materials for use in H ₂ S-containing environments in oil and gas production.	Online
NZS 5442	NZS 5442:1990 – New Zealand standard – “Specification for Reticulated Natural Gas.”	Online
	Office of Gas Safety 2001 – “Specification for Combustion Quality and Excess Air Level When Utilising Natural Gas”, September 2001.	
	Petroleum and Gas (Production and Safety) Regulation 2004 – Queensland.	
	Shnidman L. (Editor) “Gaseous Fuels” – American Gas Association. 1954.	
Gas Quality Standard	AEMO’s “Gas Quality Standard and Monitoring Guidelines (Declared Transmission System)”.	AEMO Website
	Watkins and Vaughn – Materials Performance, January 1986 – “Effects of H ₂ S Partial Pressure on the Sulphide Stress Cracking Resistance of Steel”.	

CHAPTER 2. BASIC PRINCIPLES

As these Guidelines involve matters which may increase risk to the wider community, the understanding of these Guidelines and notification procedures is critical to all Participants.

2.1. General

Reports of off-specification gas entering the system may originate from monitoring equipment at the system injection point(s), or from faxed or telephoned reports. In the event of major plant failure, there may also be supplementary notification from the Facility Operator. Major off-specification gas conditions usually arise as a result of an abnormal operating event or equipment failure.

Some gas quality monitoring equipment is located within production and storage facilities, remote from the system injection point. In these circumstances, off-specification gas quality notifications will be issued based on readings from within the production facility where there is no comparable monitoring at the injection point. This may mean that the notification of off-specification gas may occur before the gas is actually injected. It may not be possible to accurately predict the time when off-specification gas is injected.

Repeated excursions or protracted oscillation between on-specification and off-specification gas will be cause for curtailment until the Facility Operator can demonstrate these excursions have been adequately addressed. AEMO will base this assessment on the level of risk involved.

2.2. Gas Quality Data

As the decisions made using these guidelines may impact on the health and safety of the wider community, it is essential that such decisions be based on data that is practical as well as reliable.

Although notifications of off-specification gas are based on readings from monitoring equipment where feasible, these readings will be confirmed. Typical confirmation involves contacting the parties responsible for the monitoring equipment and other parties who may have additional information, and comparing related data. The confirmation process may continue after the initial notification of off-specification gas.

2.3. Responses to Off-Specification Gas

AEMO applies a hierarchy of responses to off-specification gas, based on the severity and duration of the event outside specification. The order of responses can be briefly outlined as follows, from requiring least to most action:

- **Confirm:** This response level applies to gas that is in specification, but close to the specified limit. It is a trigger point to check the gas quality monitoring equipment and confirm it is measuring correctly.
- **Notify (gas quality specification limit):** This response level applies to gas that has breached specification. It is a trigger point for Participants to be notified and for the Facility Operator to take immediate action to bring the given parameter within specification.
- **Mitigate:** This response level applies to gas that may adversely impact certain parties. It is a trigger point for actions to be taken by relevant parties to mitigate any risk from the off-specification gas and indicates possible curtailment of injections.
- **Curtail:** This response level applies to gas that may cause significant adverse impacts to one or more parties. It is a trigger point for the injection of the gas to be stopped.

Responses to injection of off-specification gas are listed in Chapter 5 and 6. Different off-specification conditions may require different responses.

The limits include specific excursion duration and a physical limit for a given parameter.

Registered Participants, such as Facility Operators, must notify AEMO under rule 289(4) as soon as they become aware that off-specification gas has been delivered at a DTS system injection point. Facility Operators should confirm and validate off-line test results before providing these to AEMO. AEMO must treat all results received as real in the absence of alternative test and/or measurement results.

AEMO will notify the relevant Facility Operator control centre by telephone when gas composition parameters reach the Confirm limit. A System Wide Notice (SWN) will be sent when the gas composition parameters reach the Notify limit.

2.4. Duration of Excursions

The Confirm and Notify limits for each gas parameter are set out in Chapter 4. They are based on a 15-minute continuous excursion or separate excursions that occur in any 30-minute period for a total of more than 15 minutes. For example, such excursions may involve a two-minute, four-minute and five-minute excursion in the same 30-minute time block.

For Gas Quality excursions with non-continuous measurement devices, the time is counted from the first off-specification measurement result to the first on-specification measurement result.

One exception for this 15-minute limit, is odorant during start-up or shut-down conditions. The Confirm and Notify limits for odorant during start-up or shut-down are based on a 30-minute continuous excursion. However, odorant concentration during this period still must be within the low or high Mitigate limits set out in Chapter 4.

2.4.1. Confirm limit

Any excursion of a gas parameter that is greater than the Confirm limit may result in the Facility Operator or the DTS Service Provider being contacted to perform confirmation and/or validation checks.

2.4.2. Notify limit

The Notify limit in this document is the gas quality specification limit as per AEMO's "Gas Quality Standard and Monitoring Guidelines (Declared Transmission System)". Any excursion of a gas quality parameter greater than the Notify limit will result in the relevant parties being notified (refer to Chapter 5 and 6) in accordance with AEMO notification procedures.

Where off-specification gas excursions are intermittent, an interval where the gas is within specification for more than 30 minutes before again exceeding the Notify limit defines the start of a separate excursion and further notifications are required.

Injection of off-specification gas for more than twelve hours (except for odorant, hydrogen sulphide and Wobbe which is 5 hours) will result in a rate reduction or curtailment of the Facility Operator. This time should be sufficient to address any operational issues that may have caused the off-specification event.

2.4.3. Mitigate limits and industry response requirements

Any excursion of a gas parameter greater than the Mitigate limit will result in the relevant affected parties being notified.

The onus is on the respective Participants to carry out any necessary mitigation for off-specification gas appropriate for their organisations based on independent expert advice. Mitigation steps may include notifications to specific categories of gas consumer.

The Mitigate limits for each gas parameter are set out in Chapter 4. The limits include specific excursion duration and a physical limit for a given parameter. For example, the Wobbe index (maximum) exceeds the Mitigate limit if it is above 52.5 MJ/m³ for 30 minutes. The Mitigate time starts from the first off-specification result and the excursion needs to be continuous before AEMO starts the Mitigate actions.

The notification period is based on the 15-minute continuous excursion or separate excursions that occur in any 30-minute period for a total of more than 15 minutes (as for Confirm and Notify limits).

Participants need to be aware that if gas quality remains outside the Mitigate limits for more than three hours, the injection will be curtailed and the source of the off-specification gas will be scheduled down until the gas can be injected at an acceptable quality.

2.4.4. Curtail limits and required response

The Curtail limits for each gas parameter are set out in Chapter 4, and in the parameter information tables. When the Curtail limit is reached, the Facility Operator will be instructed to cease injections until the gas can be injected at an acceptable quality. For example the Wobbe index (maximum) exceeds the Curtail limit if Wobbe is above 53.5 MJ/m³ for 30 minutes. The Curtail time starts from the first off-specification result and the excursion needs to be continuous before AEMO starts the Curtail actions.

The notification period is based on the 15-minute continuous excursion or separate excursions that occur in any 30-minute period for a time totalling more than 15 minutes (as for Confirm and Notify limits). The onus is on the Facility Operator to carry out any necessary mitigation for off-specification gas and the curtailment of gas injections appropriate for their organisations.

2.4.5. Reinstate Level

The Reinstate level is the quality level that the Facility Operator must be able to achieve before injection can be recommenced after curtailment. The Facility Operator must notify AEMO in writing when they are able to achieve this.

2.5. Acceptance of Off-Specification Gas for System Security

Where long-term acceptance of off-specification gas is required for continuing system security, AEMO is unlikely to accept gas with gas quality parameters more than halfway from the Notify limit to the Mitigate limit for any extended period.

These events will be treated on a case-by-case basis and risk assessed by AEMO (in consultation with Energy Safe Victoria). Any incident will be managed under AEMO's Gas Emergency Protocol³.

2.6. Offline testing and additional requirements

In general, gas quality parameters are measured by the Facility Operator or DTS Service Provider, and monitored continuously by AEMO (also known as 'real time' monitoring). However, continuous monitoring is not always feasible and offline (or laboratory) testing can be used in its place. This is typically the case for measuring contaminants such as mercury, radioactivity and elemental sulphur.

Offline testing is less frequent with the duration between results varying from days to weeks, as opposed to minutes for continuously monitored parameters. As well, the total time from sampling to the test result can take days or weeks. Due to these increased timings, the approach to gas quality limits for offline testing needs to be modified accordingly to mitigate risks from off-specification gas.

In general, the larger the excursion, the shorter the time it can be tolerated for. This is the historic basis for the Confirm, Notify, Mitigate and Curtail times. This approach has been extended for offline testing. The limits and duration of offline testing conducted by Facility Operators can be found in Table 6.

In addition to the operational responses covered by section 2.4, AEMO will work with the Facility Operator to further minimise the overall risk, which may include operational responses such as reducing or stopping the production rate of the offending field(s).

³ AEMO Gas Emergency Protocol. <http://www.aemo.com.au/Gas/Emergency-management/Victorian-role>.

2.6.1. Response to incorrect results

In the case of incorrect results, AEMO will work with the Facility Operator to balance the risk of losing gas supply versus the risk of injecting off-specification gas. AEMO will consider historic baseline test results, any treatment of the parameter (i.e. guard beds or coalesces) and operational responses that are documented in the Gas Quality Monitoring Plan. The plan should also include an agreed re-test period, where the Facility Operator will investigate and rectify any potential issues during this period.

In the event of an offline test result that could be incorrect, the following re-testing and risk assessment processes will be used:

- Re-testing as soon as possible (within 48 hours).
- Comparison to historic test results and background levels.
- Review of other factors (plant operating conditions, testing equipment performance etc.).

If AEMO suspects a measurement error but cannot positively rule it out, AEMO will notify the market by a SWN (refer to Section 3) that 'measurement error is suspected' until such time as it can be confirmed.

CHAPTER 3. NOTIFICATION PROTOCOLS

Rule 289 (6)(b) requires AEMO to notify affected Participants where it accepts or intends to accept off-specification gas. To this end, system wide notices (SWN) are issued to relevant Participants (refer to Section 3.1), when gas quality parameters exceed the Notify, Mitigate and Curtail levels.

To register for these notices, Participants should contact AEMO's Information and Support Hub⁴. The SWNs can be configured for email and/or text message alerts. Participants should ensure they use the SWN information to then communicate to affected end customers.

For the Confirm level, AEMO will only contact the Facility Operator (by phone) that injected the gas to confirm the reading, as the gas is still within specification.

The Notify, Mitigate and Curtail SWNs contain information to inform Participants when off-specification gas was injected, the amount and duration (if known). These are explained in more detail below.

All parties registered for SWNs are notified of a gas quality excursion. Based on the information received from the Facility Operator, AEMO if possible will include the impacted zone in the SWN. It may not always be feasible for AEMO to accurately determine which locations may or may not be affected. In these cases, AEMO will notify that all zones are impacted.

3.1. System Wide Notices (SWN)

The SWN includes the Facility Operator that injected the gas, the off-specification gas quality parameter and the level, time of notification, flow rate and, if known, the impacted zone and likely duration of the excursion. All information is based on the best-known information at the time of the message.

For example, a SWN may contain:

[Location] – [gas quality parameter] off spec. – HIGH/LOW – [Level] – [First Value] at HHMM hrs DD/MM/YYYY – [Current Rate] TJ/h – [Estimated Duration] HHMMhrs – [Zone] Impacted.

where:

- Level is either Notify, Mitigate or Curtail.
- Rate is based on the current scheduled rate at the time of the excursion.
- Duration is based on the best information provided by the Facility Operator that injected the gas at the time of the initial SWN. If it is not clear, AEMO will leave this as 'unknown.'

Tables 1-3 contain abbreviations for Location, Gas Quality Parameter and impacted zone, required because SWNs notices are limited to 160 characters.

Once the measured gas quality parameter returns to the Normal or within the "Notify" limit and remains so for more than 30 minutes, a SWN notice will be sent out. For example:

[Location] – [gas quality parameter] Returned to Specification – at HHMM hrs DD/MM/YYYY.

If the parameter stays-off specification and curtailment is possible, further SWNs will be sent out 15 minutes later, updating all registered participants. For example:

[Location] – [gas quality parameter] off spec. – HIGH/LOW – Level – [First Value] at HHMM hrs DD/MM/YYYY, possible curtailment in HHMM hrs.

If the curtailment of off-specification gas impacts system security, this will be managed under the AEMO Gas Emergency Protocols in consultation with Energy Safe Victoria (ESV)⁵.

⁴ Contact details available at <http://www.aemo.com.au/Contact-us>

⁵ AEMO Gas Emergency Protocol. <http://www.aemo.com.au/Gas/Emergency-management/Victorian-role>.

Table 1 Location

ACRONYM	LOCATION
LONGFORD	Longford
IONA	Iona Underground Gas Storage
BASSGAS	Bass Gas
SEAGAS	SEA Gas
TASHUB	Tasmanian Gas Pipeline
CULCAIRN	Culcairn
DNG LNG	Dandenong LNG
MORTLAKE	Mortlake
OTWAY	Otway
VICHUB	Vic Hub

Table 2 Gas Quality Parameter

ACRONYM	GAS QUALITY PARAMETER
WOBBE	Wobbe
HHV	Higher Heating Value
O2	Oxygen
H2S	Hydrogen sulphide
TOTSULP	Total sulphur
H20DP	Water dew point
H2O	Water content
HCDP	Hydrocarbon Dew Point
INERT	Total inerts
ODO	Gas odourisation
MERCSUL	Mercaptan sulphur
TEMP	Temperature
OIL	Oil
OBJC	Objectionable constituents
MERC	Mercury
RAD	Radioactivity
ELEMSUL	Elemental sulphur

Table 3 Impacted Zones

ACRONYM	ZONE
ALL	All Zones
LMP	Includes all of Gippsland and the Lurgi pipeline
MELB	Melbourne
NTH	Northern including Bendigo.
SWP	Includes Western, Ballarat and Geelong zones

CHAPTER 4. SUMMARY OF GAS QUALITY LIMITS

Table 4 Online Gas Quality Limits

Parameter		Confirm (15 minutes)	Notify (15 minutes)	Mitigate (curtail if more than 3 hours)	Curtail	Reinstate levels ⁶
REQUIRED BY GAS SAFETY (GAS QUALITY) REGULATION						
Wobbe maximum (MJ/m ³)		51.5	52.0	52.5 30 minutes	53.5 30 minutes	52.0
Wobbe minimum (MJ/m ³)		47.0	46.0	45.0 30 minutes	44.0 30 minutes	46.0
HHV maximum (MJ/m ³)		41.8	42.3	42.8 30 minutes	44.3 30 minutes	42.3
Oxygen maximum (mol %)		0.15%	0.2%	2% 30 minutes	5% 30 minutes	2%
Hydrogen sulphide (H ₂ S) maximum (mg/m ³)		4.5	5.7	5.8 30 minutes	10 30 minutes	5.7
Total sulphur maximum (mg/m ³)		45	50	100 30 minutes	200 30 minutes	50
Water dew point @ 15,000 kPa		-2.0°C	0.0°C	4.0°C 30 minutes	6.0°C 30 minutes	0.0°C
Water content (H ₂ O) maximum (mg/m ³)		65	73	93 30 minutes	105 30 minutes	73
Hydrocarbon Dew Point @ 3,500 kPag		1°C	2°C	3°C 30 minutes	5°C 30 minutes	2°C
Total inerts maximum (mol %)		6.5%	7.0%	7.2% 30 minutes	7.5% 30 minutes	7.0%
Gas odourisation minimum (mg/m ³)		N/A ⁷	7.0 ⁸	4.0 30 minutes	2.0 120 minutes	7.0
Gas odourisation maximum (mg/m ³)		N/A ⁹	14.0 ¹⁰	24 30 minutes	See Odourisation ¹¹	14.0
REQUIRED BY AEMO						
Mercaptan sulphur maximum (mg/m ³)		4.5	5.0	10.0 30 minutes	See Mercaptan Sulphur ¹²	

Temperature maximum		45°C	50°C	55°C 30 minutes	60°C 30 minutes	50°C
Temperature minimum (unless HCDP or H ₂ O dew point is off specification)		3.0°C	2.0°C	-2.0°C 24 hours	-10.0°C 2 hours	2.0°C

Table 5 Offline Gas Quality Limits

Parameter		Confirm	Notify	Mitigate (curtail if more than 7 days)	Curtail	Reinstate levels ¹³
REQUIRED BY GAS SAFETY (GAS QUALITY) REGULATION						
Oil (mL/TJ) ¹⁴			20			20
Objectionable constituents	Refer to Objectionable Constituents section (this does not including mercury, radioactivity and elemental sulphur captured below).					
Mercury (µg/m ³)		N/A	1.0	4.0	7.0	1.0
Radioactivity (Bq/m ³)		N/A	600	2,500	5,000	600
Elemental Sulphur (µg/m ³)		N/A	1.0	See Elemental Sulphur ¹⁵	See Elemental Sulphur ¹⁵	1.0

⁶ The gas must be within the boundary of the Reinstate level (i.e. with the specification) for injection to recommence.

⁷ As short term Odorant exceedances average out overtime, the Confirm limit is not required for odorant as the gas is within specification.

⁸ The Notify limits for odorant during start-up or shut-down is based on a 30-minute continuous excursion if concentration is within the mitigate limits.

⁹ Refer to footnote 7.

¹⁰ Refer to footnote 8.

¹¹ Refer to the Curtailment section on Odorant in section 5.11.

¹² Refer to the Curtailment section on Mercaptan Sulphur in section 6.1.

¹³ The gas must be within the boundary of the Reinstate level (i.e. with the specification) for injection to recommence.

¹⁴ As there are no suitable real time methods for measurement of entrained oil, compliance is verified from retrospective logging and the excursion durations in the table do not apply.

¹⁵ Refer to the Elemental Sulphur in section 5.15.

CHAPTER 5. PARAMETERS SPECIFIED IN THE GAS SAFETY (GAS QUALITY) REGULATIONS INCLUDING PARAMETERS SPECIFIED IN AS 4564

5.1. Wobbe Index Maximum

Description	<p>The Wobbe Index of a gas is an indicator of its combustion acceptability for a given population of appliances. It is the most significant parameter in gas combustion safety.</p> <p>The Wobbe Index is the higher heating value (HHV) divided by the square root of the relative density (RD), sometimes called the specific gravity.</p> $WobbeIndex = \frac{HHV}{\sqrt{RD}}$ <p>Gas with a Wobbe Index that is too high can result in overheating and eventual burning out or perforation of heat exchangers, and “spillage” (some combustion products entering the room rather than all passing up the flue).</p> <p>High Wobbe Index gases can also cause excessive carbon monoxide formation. While this may not be an issue with flued appliances, there are unflued appliances and possibly appliances with faulty fluing systems.</p> <p>High Wobbe Index gas can increase the likelihood of soot build-up on finned heat exchangers.</p> <p>Industrial furnaces adjusted to the minimum air for combustion may also be adversely affected if “combustion quality excess air” levels (minimum air/gas ratio) set by Energy Safe Victoria (ESV) have not been adhered to. High Wobbe Index gases tend to have a higher combustion air requirement. If a furnace has been adjusted for low Wobbe Index gases, potential exists for these furnaces to have insufficient air for combustion when receiving very high Wobbe Index gas. The resulting incomplete combustion may create enough carbon monoxide and hydrogen to cause an explosion if additional air is inadvertently admitted to the combustion chamber during operation.</p>
Limits	<p>Short-term small excursions can be tolerated from a safety perspective provided the average levels are kept within specification.</p> <p>The Curtailment limit has been chosen to ensure that levels of carbon monoxide and hydrogen created by incomplete combustion will not create an explosive mixture with air. This limit accommodates a wide range of gas compositions for furnaces adjusted at the low Wobbe Index limit, provided minimum air/gas ratios set by ESV are adhered to.</p>

Wobbe Index maximum

	Confirm	Notify	Mitigate	Curtail	Reinstate Level
Wobbe Index (MJ/m ³)	51.5	52.0	52.5	53.5	52.0
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	When the Notify level has been exceeded continuously for more than 15 minutes (or for a total of more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols. The affected parties will also be notified when Mitigate and Curtail limits are exceeded.
Mitigation	Mitigation steps may include: <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring plant under control. Participants may choose to notify their customers based on their assessment of the situation. Restricting the transmission of off-specification gas to limited areas (using line pack to maintain other areas) until the episode has passed.
Curtailment	Once the curtailment limit has been breached for the specified time, the injecting party will be instructed to cease injection. Note that the Curtailment may also occur under Mitigation above.
Reinstatement	The injection of gas can be reinstated once the gas quality is brought to within the Reinstatement Level above.

5.2. Wobbe Index Minimum

Description	$WobbeIndex = \frac{HHV}{\sqrt{RD}}$ <p>A low Wobbe Index can result in flame instability, “flashback”, and ignition difficulties, which may lead to flame loss and resultant gas accumulations where there is no auto shut-off. Low Wobbe index gases may increase carbon monoxide formation in surface-combustion tile type appliances.</p>
Limits	<p>Short-term small excursions can be tolerated from a safety perspective provided the average levels are kept within specification.</p> <p>The Curtailment limit has been set at the AGA test gas limit. At these limits, AGA approved (Type A) domestic appliances should still function safely.</p>

Wobbe Index minimum

	Confirm	Notify	Mitigate	Curtail	Reinstatement level
Wobbe Index (MJ/m ³)	47.0	46.0	45.0	44.0	46.0
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total, more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail Limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring the plant under control. Participants may choose to provide notifications to their customers based on their assessment of the situation. Restricting the transmission of <i>off-specification gas</i> to limited areas (using line pack to maintain other areas) until the episode has passed.
Curtailment	<p>Once the Curtailment limit has been breached for the specified time, the injecting party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once the gas quality is brought to within the Reinstatement Level above.</p>

5.3. Higher Heating Value Maximum

Description	<p>The higher heating value of a gas is defined as: “The amount of energy, in MJ/m³, released when one cubic meter of dry gas, at standard conditions, is completely burnt in air. With the products of combustion brought to standard conditions, and the water produced by combustion condensed to the liquid state.”</p> <p>Testing, as part of AS 4564-2011, has found that gases with a higher heating value over 42.3 MJ/m³ can result in the build-up of soot on finned heat exchangers, even if the Wobbe Index is below 52 MJ/m³. In severe cases, soot build-up can block the flue and combustion products can spill into a building through the burner.</p>
Limits	<p>Short-term small excursions can be tolerated from a safety perspective provided the average levels are kept within specification.</p> <p>The Curtail limit is relatively close to the Notify limit as sooting problems may occur at values close to the Notify limit, particularly for gases with a high Wobbe Index.</p>

Higher Heating Value Maximum

	Confirm	Notify	Mitigate	Curtail	Reinstatement level
Heating value (MJ/m ³)	41.8	42.3	42.6	43.0	42.3
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols. The affected parties will also be notified when Mitigate and Curtail limits are exceeded.
Mitigation	Mitigation steps may include: <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the injecting facility to change injection rate to help bring the plant under control. Participants may choose to notify their customers based on their assessment of the situation. Restricting the transmission of off-specification gas to limited areas (using line pack to maintain other areas) until the episode has passed.
Curtailment	Once the Curtailment limit has been breached for the specified time, the Injecting Party will be instructed to cease injection. Note that Curtailment may also occur under Mitigation above.
Reinstatement	The injection of gas can be reinstated once the gas quality is brought to within the Reinstatement Level above.

5.4. Oxygen Maximum

Description	Oxygen can cause corrosion within pipelines. At very high levels, there is the potential to form an explosive mixture.
Limits	Relatively long periods of higher-than-specification oxygen content can be tolerated from a safety perspective, provided the average levels are kept within specification. The Curtailment limit is based on keeping the gas and oxygen mixture above the upper explosive limit for natural gas, and is aligned with the Total Inerts limit.

Oxygen maximum

	Confirm	Notify	Mitigate	Curtail	Reinstatement level
Oxygen Maximum. (mol %)	0.15%	0.2%	2.0%	5.0%	2.0%
Excursion Duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>If the oxygen content is over the Mitigate limit for more than three hours, the injection will be curtailed.</p> <p>Scheduled quantities may be adjusted down.</p>
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.</p> <p>Note that this limit is unlikely to ever be reached because, in practice, there is not enough oxygen in the system to reach the curtailment figure.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once gas quality is brought to within the Reinstatement Level above.</p>

5.5. Hydrogen Sulphide Maximum

Description	<p>Hydrogen sulphide (H₂S) is a corrosive, poisonous gas that has a cumulative effect on pipelines and copper components in gas installations.</p> <p>Short periods of high hydrogen sulphide can be tolerated from a safety perspective, provided the average levels are kept within specification.</p> <p>Hydrogen sulphide is also a stress-cracking agent for steel. The likelihood of creating stress cracks depends on the partial pressure of H₂S. Higher gas pressures require a lower H₂S level. A maximum partial pressure of 0.1 kPa (0.015 psi) was used to define the Mitigation and Curtailment limits, as it is the lowest partial pressure reported to create stress cracking¹⁶. This provides a margin for safety over the NACE standard (MR01750/ISO 15156 -2003) 0.3 kPa (0.05 psi) H₂S partial pressure lower limit requirement for resistant steels.</p> <p>High hydrogen sulphide levels can pose a threat to the compressed natural gas (CNG) cylinders of natural gas vehicles (NGV) as they are exposed to pressures up to 26,000 kPa.* The current standard for NGV cylinders (AS 4838-2002) specifies that they should be designed to handle H₂S levels up to 23 mg/m³ however some cylinders may pre-date the first issue of the standard (2002)¹⁷.</p>
Limits	<p>The Mitigate limit has been chosen at the H₂S level likely to be of concern for NGV cylinders (not compliant with AS 4838-2002) being exposed to pressures up to 26,000 kPa.</p> <p>The Curtail limit has been chosen based on an expected maximum transmission pressure of 15,000 kPa. Gas injected into the AEMO-operated gas transmission system may pass into connected 15,000 kPa transmission systems.</p>

¹⁶ Watkins & Vaughn, 1986

¹⁷ AS 4838-2002 (section 4.2) – the maximum filling pressure limit for NGV cylinders.

Hydrogen Sulphide Maximum

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Hydrogen sulphide (H ₂ S) maximum (mg/m ³)	4.5	5.7	5.8	10.0	5.7
Excursion Duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the injecting facility to change injection rate to help bring the plant under control. Participants should notify users of CNG that they should not refill cylinders that may be susceptible to H₂S concentrations of up to 10 mg/m³ until after high H₂S has been eliminated from the gas transmission system. This is the most critical H₂S mitigation. Cylinders constructed to AS 4838-2002 “Gas cylinders – High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles” would not require any mitigation steps under these guidelines. Participants should to notify consumers known to be affected by sulphur compounds in gas (e.g. glass manufacturers).
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above. The notification to users of CNG should still be made by the Participants.</p>
Reinstatement	<p>The injection of gas can be reinstated once gas quality is brought to within the Reinstate Level above.</p>

5.6. Total Sulphur Maximum

Description	<p>This parameter is the quantity of sulphur contained in gas compounds. This includes any sulphur-containing odorants.</p> <p>This specification is related to air pollution and indoor air quality control. High levels of sulphur compounds in gas increase the amount of sulphur dioxide (SO₂) created when the gas is burnt and may lead to corrosion of appliances.</p> <p>Sulphur compounds in the gas may lead to deposits elemental sulphur in pipelines.</p> <p>The sulphur compounds may have a very strong unpleasant smell and may lead to “nuisance” leak reports.</p> <p>Short excursions can be tolerated from a safety perspective provided the average levels are kept within specification.</p>
Limits	The Mitigate limit is based on twice the injection specification limit and the Curtail limit on four times the injection specification limit.

Total sulphur maximum

	confirm	notify	mitigate	curtail	reinstate level
Sulphur Maximum. (mg/m ³)	45	50	100	200	50
Excursion Duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>The onus is on the respective businesses to carry out any necessary mitigation steps appropriate for their organisations as they see fit.</p> <p>If the total sulphur content is over the Mitigate limit for more than three hours, then the injection will be curtailed.</p> <p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the injecting facility to change the injection rate to help bring the plant under control. Participants should notify consumers known to be affected by sulphur compounds in the gas [e.g. glass manufacturers]. Gas retail and distribution businesses may prepare for an increase in reported gas leaks.
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	The injection of gas can be reinstated once the gas quality is brought to within the Reinstate Level above.

5.7. Water Content / Dew Point

Description	<p>Excess water in natural gas can condense and absorb CO₂ and sulphur compounds from the gas, thus creating a corrosive liquid in the pipe.</p> <p>Excess water in natural gas can also cause formation of solid or semi-solid hydrates. Hydrates are an ice-like mix of water and hydrocarbons. Hydrates can block or cause problems in metering equipment, pressure regulators or the pipeline itself. There is potential for hydrates to block pressure control-sensing lines.</p> <p>There is also potential to form hydrates in high-pressure NGV cylinders.</p> <p>Short-term small excursions can be tolerated from a safety perspective, provided the average levels are kept well within specification.</p> <p>To provide for uniformity in reporting, the water content is the parameter monitored and reported.</p>
Limits	<p>For the purposes of gas injected at an injection point, the relevant transmission pressure is deemed to be 15,000 kPa unless otherwise approved by AEMO. For typical natural gas compositions, a 0°C dew point corresponds to a water content of 73 mg/m³, and AEMO will use this as the basis for limits in these guidelines.</p> <p>The Confirm limit (65 mg/m³) is based on a water dew point of -2°C at 15,000 kPa.</p> <p>The Notify limit (73 mg/m³) is based on a water dew point of 0°C at 15,000 kPa.</p> <p>The Curtailment limit of 6°C is based on maintaining a water dew point margin that is 6°C below Victoria's winter ground temperature (12°C). A water dew point of 6°C at 15,000 kPa corresponds to a water content of 105 mg/m³.</p> <p>The 6°C margin between the winter ground temperature and the Curtailment limit is to allow for Joule Thompson (JT) cooling that may occur at regulator stations, plus a small additional safety factor because of the potential for (solid) hydrates to block regulators and pressure control sensing lines.</p>

Injection temperature considerations

If the gas injection temperature is below 2° (i.e. Notify level) and the water content is above 73 mg/m³ (i.e. Notify level), the injection should be curtailed if the injection pressure is above 11,000 kPa.

If the gas injection temperature is below 2° (i.e. Notify level) and the water content is above 93 mg/m³ (i.e. Mitigate level), the injection should be curtailed if the injection pressure is above 7,000 kPa.

If the gas injection temperature is below -2° (i.e. Mitigate level) and the water content is above 73 mg/m³ (i.e. Notify level), the injection should be curtailed if the injection pressure is above 4,500 kPa.

Water content / water dew point

Both parameters to be met	Confirm	Notify	Mitigate	Curtail	Reinstate level
Content (H ₂ O) Maximum (mg/m ³)	65	73	93	105	73
Dew point @ 15,000 kPa	-2° C	0° C	4° C	6° C	0° C
Excursion duration (minutes)	15	15	30	30	N/A

The equivalent water dew point readings are shown for information only; monitoring is based on water concentration.

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>If the water content is over the Mitigate limit for more than three hours, the injection will be curtailed.</p> <p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Scheduled quantities may be adjusted down. • Allowing the injecting facility to change injection rate to help bring the plant under control. • The temperature settings of pre-heaters at pressure reduction stations may be increased to reduce the risk of formation of ice or liquid water. • The gas retail businesses should notify NGV refillers.
Curtailment	<p>Once the curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once the gas quality is brought to within the Reinstatement Level above.</p>

5.8. Hydrocarbon Dew Point

Description	<p>The hydrocarbon dew point is the temperature at which hydrocarbon liquids begin to condense. A high hydrocarbon dew point may mean that liquid can collect and form waves or “slugs” of liquid which could travel along the pipeline.</p> <p>These slugs of liquid can potentially damage flow regulation and measuring equipment and may cause local loss of supply. Liquids may also pass into the distribution system and cause damage to consumers’ meters and appliances.</p> <p>The hydrocarbon dew point is a measure of the point at which hydrocarbon liquids start to form. It does not allow a prediction of the quantity of liquid that will condense at temperatures below the dew point.</p> <p>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 regulating stations.</p> <p>Short-term small excursions can be tolerated from a safety perspective provided the average levels are kept well within specification.</p> <p>There are relatively few purpose-built permanent liquid “slug catchers” in the DTS or at withdrawal points, so even relatively small quantities of liquid may create problems.</p>
Limits	<p>The Curtailment limit of 5°C is based on a hydrocarbon dew point that is 7°C below Victoria’s winter ground temperature (12°C). The 7°C margin between the winter ground temperature and the Curtailment limit is to allow for Joule Thompson cooling that may occur at regulator stations, which may cool the gas significantly below 12°C and that may increase the actual dew point at pressures other than 3,500 kPa.</p> <p>Note that the maximum dew point temperature (cricondentherm) may not be at the 3,500 kPa pressure in AS 4654.</p> <p>It should be noted that actual gas temperature might be significantly below the local ground temperature if pressure reduction stations are upstream. This should be taken into account in the design of gas withdrawal and pressure reduction installations.</p>

Injection temperature considerations:

If the gas injection temperature is below the hydrocarbon dew point (@3,500 kPa) temperature, the injection should be curtailed if the injection pressure is below 6,000 kPa.

The calculation of hydrocarbon dew point is not precise and the risk of liquid drop-out is high when the calculated hydrocarbon dew point and gas temperature are similar.

Hydrocarbon dew point

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Hydrocarbon dew point @ 3,500 kPa	1.0° C	2.0° C	3.0° C	5.0° C	2.0° C
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>If the hydrocarbon dew point is over the Mitigate limit for more than three hours, the injection will be curtailed.</p> <p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Scheduled quantities may be adjusted down. • Allowing the injecting facility to change injection rate to help bring the plant under control. • Participants should to notify consumers likely to be affected by high hydrocarbon dew point [e.g. fuel cells, large gas engines]. • The temperature settings of pre-heaters at pressure reduction stations may be increased to reduce the risk of liquids forming. • Responsible parties should monitor the operation of regulator stations likely to be affected.
Curtailement	<p>Once the curtailment limit has been exceeded for the specified time, the injecting party will be instructed to stop injections unless they can demonstrate that there is no safety hazard. The Injecting Party would need to show that the gas injected only contains quantities of liquids that could be handled safely within the transmission system.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once gas quality is brought to within the Reinstate Level above.</p>

5.9. Total Inerts Maximum

Description	<p>Inerts in natural gas under the Gas Safety (Gas Quality) Regulations are carbon dioxide (CO₂), nitrogen (N₂), helium (He), argon (Ar) and oxygen (O₂). Where a process gas chromatograph is used to measure gas composition, the total inerts is obtained by adding the mol % of the CO₂ and N₂ readings from the chromatograph. The N₂ reading will actually include the O₂ and Ar composition. Any helium content would have to be added separately. Mol % is essentially equivalent to the volume %.</p> <p>Note that for the purposes of this document and for consistency with the regulations, oxygen is classed as an “inert”.</p> <p>Inerts by themselves do not create a safety hazard. The specification for inerts is a method of controlling the levels of non-methane hydrocarbons such as ethane or propane. Limiting the total inerts in a gas restricts the non-methane hydrocarbons that can be present in the gas without exceeding the Wobbe Index limits. High non-methane hydrocarbon levels may cause incorrect combustion and create soot in gas appliances.</p>
Limits	<p>The level of inerts is relatively high compared to what has been distributed in Victoria in the past, which is why the Mitigate and Curtail limits are set only slightly above the specification (Notify) limit.</p>

Total inerts maximum

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Inerts maximum (mol %)	6.5%	7.0%	7.2%	7.5%	7.0%
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Scheduled quantities may be adjusted down. • Allowing the injecting facility to change the injection rate to help bring the plant under control. • Retailers could notify domestic consumers to ensure heaters are not left unattended for extended periods. • Retailers could notify operators of industrial burners that burners might require adjustment to burn correctly and re-adjustment when gas quality returns to normal. • Retailers could notify manufacturing plants that using natural gas as a feedstock where high carbon dioxide or nitrogen levels may impact their processes.
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the Injecting Party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once gas quality is brought to within the Reinstate Level above.</p>

5.10. Objectionable Constituents

As stated in AS 4564, 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 in normal work operations or usage;
- b) Unsaturated or aromatic hydrocarbons to an extent which causes unacceptable sooting; or
- c) Other substances that cause damage to, or problems in the 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.

For mercury, radioactivity and elemental sulphur; refer to sections 5.13 to 5.15.

Description	Solid and liquid substances can collect on meters, moving parts of compressors, valves, and pipe walls to cause inefficiencies and malfunctions. They can plug consumers' burners, extinguish pilots, and interfere with process equipment or be hazardous to health.
Examples	Objectionable substances sometimes found in gas transmission pipelines include liquid hydrocarbons, compressor lubricating oils, amines and glycols from processing plants, mill scale, valve grease, and dust. Substances hazardous to health include aromatic hydrocarbons, halogens, halogenated hydrocarbons, polychlorinated biphenyls (PCBs), and mercury vapour.
Limits	There are no facilities to provide continuous monitoring of "objectionable constituents", so they are usually detected during regular inspections and maintenance by asset owners. The excursion duration does not apply for objectionable constituents. AEMO should be notified of the presence of objectionable constituents along the gas supply chain as soon as is practical. AEMO will notify all affected parties only after due notification by a Participant or responsible person of the detection of any such objectionable constituents. Complaints by consumers can be taken as an indication that the quantity of objectionable constituent has exceeded the limit to an extent that causes problems. Limits for some objectionable constituents are contained in the AEMO "Gas Quality Standard and Monitoring Guidelines".
Curtailement	An injecting party that injects gas containing objectionable constituents to an unacceptable level will be instructed to cease injection.
Reinstatement	Reinstatement of a curtailed injection source will be based on rectification of the matters allowing the objectionable constituents to be injected.

5.11. Gas Odourisation

The Gas Safety (Gas Quality) Regulations require that 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.

Description	<p>Odorants (chemicals that have a distinct smell) are added to the normally odourless natural gas to facilitate the detection of leaks.</p> <p>While under-odorisation of natural gas creates a community safety risk, over-odorisation creates a community cost in attending to “nuisance” leak reporting. Odorants can sometimes lose their impact (fade) by absorption onto the walls of pipelines or by absorption in liquids present in the pipeline. Pipeline owners should allow for this during the commissioning of new pipelines and should ensure that gas exiting the pipeline is adequately odorised.</p>
Acceptable level	<p>The preferred gas odorisation is a blend of 70% tetrahydrothiophene (THT) and 30% tertiary butyl mercaptan (TBM) injected into the gas stream at a rate between 7 -14 mg/m³ of gas. This gas odorisation regime has traditionally been considered adequate to meet the requirements of the Gas Safety (Gas Quality) Regulations.</p> <p>The preference is based on what has been used in the past as the odour is familiar to the community. Other odorant blends and injection rates are acceptable if they meet the requirements of the Gas Safety (Gas Quality) Regulations.</p> <p>At some sites, where gas previously withdrawn from the transmission system is re-injected, the odour levels are “topped up” to compensate for changes in odorant concentration associated with gas processing. At these sites specific odour alarm levels have been set to ensure adequate final odour levels.</p> <p>Odorant injection rates in the range of 7 to 14 mg/m³ of gas are acceptable; rates up to 23 mg/m³ (usually limited-term associated with “conditioning” new pipelines) are acceptable provided the injection is such that they do not create “nuisance” leak reporting. Blending of highly odorised gas with “normally” odorised gas reduces the likelihood of “nuisance” leak reporting.</p>

Lower limits (under odorisation)

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Odorant (mg/m ³)	N/A	7.0	4.0	2.0	7.0
Excursion duration (minutes)	N/A	15	30	120	N/A

The above table does not cover “top up” odorisation.

Upper limits (over odorisation)

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Odorant (mg/m ³)	N/A	14.0	24.0	See section below.	14.0
Excursion duration (minutes)	N/A	15	30	See section below.	N/A

The above table does not cover limited term “conditioning” odorisation where higher limits may be approved for specific periods.

Notifications	<p>In the event of odorant injection equipment failure, or if the indicated odour injection for previously un-odorised gas falls below 7 mg/m³ (TBM/THT mix) or rises above 14 mg/m³ for more than 15 minutes continuously or 30 minutes in total during start-up or shut-down¹⁸, the organisation responsible for gas odorant injection will be notified. Similarly, if “top-up” odourisation falls outside the appropriate agreed levels, the organisation responsible for gas odorant injection will be notified.</p> <p>If either of the above conditions persists for more than a further 15 minutes continuously (or more than 15 minutes in any 30 minute period) or 30 minutes during start-up or shut-down¹⁹, the affected parties will be notified according to AEMO notification protocols.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Scheduled quantities may be adjusted down. • Gas transmission or distribution organisations may apply supplementary odorant “dosing” into the transmission or distribution pipelines. • Participants should notify gas consumers.
Curtailment	<p>Once the lower curtailment limit has been exceeded for the specified time, the Injecting Party will be instructed to cease injection to the extent possible consistent with system security. Other (odorised) supplies will be used and the under-odorised supply will be reduced to the maximum extent possible.</p> <p>High odorant is not a cause for curtailing injection on safety grounds by itself unless the total sulphur curtailment level is exceeded.</p>
Reinstatement	<p>The injection of gas can be reinstated once the odourisation process has been rectified.</p>

¹⁸ Odorant concentration during start-up or shutdown must remain within the mitigate limits for the 30 minutes to apply.

¹⁹ Refer to footnote 13.

5.12. Oil

Description	<p>The limit for oil contamination comes from AS 4564, which is based on the Queensland Petroleum and Gas (Production and Safety) Regulation 2004, which was based on Australian Pipelines and Gas Association (APGA) good practice for compressor station operation. The limit is an acknowledgement that while undesirable, it is almost inevitable that some oil from compressors and facilities will escape.</p> <p>The limit is intended to restrict oil accumulation in transmission systems to manageable levels, and avoid operation and appliance safety problems in distribution systems.</p> <p>There are currently no suitable real time methods for measuring entrained oil. Compliance is verified by retrospective logging of oil collected from filters or other entrapment elements. Therefore the excursion duration does not apply for oil.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Installation of downstream filters and coalescer. • Installation of dry seal compressors. • Participants should notify consumers likely to be affected.
Curtailment	<p>Once the limit has been exceeded for the specified time, the Facility Operator (or compressor operator) will be instructed to cease injection (or compressor operation) to the extent possible consistent with system security.</p>
Limits	<p>Limit is 20 mL/TJ for oil concentration.</p>
Reinstatement	<p>The injection of gas (or use of a compressor) can be reinstated once the oil contamination issue has been rectified.</p>

5.13. Mercury

Description	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 limits below were chosen to constrain air-borne mercury to well below the occupational health exposure limit set by Safe Work Australia. ²⁰
Limits for Offline Monitoring	<p>The mitigate limit has been chosen at approximately half the level where liquid mercury is expected not to condense in methane at cryogenic temperatures (such as Liquefied Natural Gas (LNG)). The curtail limit has been chosen at a level below where liquid mercury is expected not to condense in methane at cryogenic temperatures.</p> <p>Both the Mitigate and Curtail limits are set at levels well below the long-term tolerable concentration from a health perspective.²¹</p>

Total Mercury Maximum – Offline

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Mercury maximum ($\mu\text{g}/\text{m}^3$)	N/A	1.0	4.0	7.0	1.0

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period) for online monitoring, and when the Notify level has been exceeded by one confirmed test result for offline monitoring, affected parties will be notified according to AEMO notification protocols (refer to Chapter 3).</p> <p>The affected parties will also be notified when the Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Reducing or stopping the production rate of the offending field(s). Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring the plant under control. <p>Participants should notify consumers likely to be affected by high mercury.</p>
Curtailment	<p>Once the curtailment limit has been exceeded for the specified time, the Injecting Party will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once the gas quality is brought to within the Reinstate Level above.</p>

²⁰ Safe Work Australia Work Place Exposure Standard for Airborne Contaminants. As viewed at 1 May 2017.

²¹ Ambient air pollution by mercury (Hg) Position Paper. www.ec.europa.eu/environment/archives/air/pdf/pp_mercury.pdf. Viewed 1 May 2017.

5.14. Radioactivity

Description	Radioactivity in natural gas is mainly due to radon. Radon is a colourless, odourless, tasteless gas and is considered to be a health hazard due to its radioactivity. The limits below are based on recommended levels set by the World Health Organisation. ²²
Limits for Offline Monitoring	<p>The Mitigate limit has been set at approximately a quarter of the long-term tolerable concentration from a health perspective recommended by the World Health Organisation based on exposure to radon in natural gas.</p> <p>The Curtail limit has been set at half of the long-term tolerable concentration from a health perspective based on exposure to radon in natural gas.</p>

Total Radioactivity Maximum – Offline

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Radioactivity maximum (Bq/m ³)	N/A	600	2500	5000	600

Notifications	<p>When the Notify level has been exceeded by one confirmed test result, affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Reducing or stopping the production rate of the offending field(s). Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring the plant under control. <p>Participants should notify consumers likely to be affected by high radon levels.</p>
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the Facility Operator will be instructed to cease injection.</p> <p>Note that Curtailment may also occur under Mitigation above.</p>
Reinstatement	<p>The injection of gas can be reinstated once the gas quality is brought to within the Reinstate Level above.</p>

²² WHO handbook on indoor radon: a public health perspective. http://www.who.int/ionizing_radiation/env/9789241547673/en/. Viewed 1 May 2017.

5.15. Elemental Sulphur

Description	Elemental sulphur deposition can cause operational problems in transmission systems. Short periods of high elemental sulphur may be tolerated from a safety perspective, but this will be treated on a case-by-case basis. If the excursions are significant, the increased likelihood of elemental sulphur formation and deposition may lead to operational problems.
Limits for Offline Monitoring	N/A

Total Elemental Sulphur – Offline

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Elemental Sulphur maximum ($\mu\text{g}/\text{m}^3$)	N/A	1.0	See section below.	See section below.	1.0

Notifications	When the Notify level has been exceeded by one confirmed test result, affected parties will be notified according to AEMO notification protocols.
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Reducing or stopping the production rate of the offending field(s). Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring the plant under control. <p>Participants should notify consumers likely to be affected by high elemental sulphur levels.</p>
Curtailment	High elemental sulphur may not be the single cause for curtailing injection on safety grounds, unless the reliability and security of the system is impacted. This will be assessed by a case-by-case basis.
Reinstatement	The injection of gas can be reinstated once the gas quality is brought to within the Reinstate Level above.

CHAPTER 6. PARAMETERS SPECIFIED BY AEMO

6.1. Mercaptan Sulphur Maximum

Description	<p>This is an AEMO specification only and relates to the smell of gas before odorant is added. Short periods of high mercaptan sulphur can be tolerated from a safety perspective. If the excursions are significant, increased “nuisance” gas leak reports can be expected unless odorant is reduced to compensate.</p> <p>Mercaptan sulphur is continuously measured if initial measurements indicate that significant levels of mercaptan sulphur are present in the gas-producing geological formations.</p>
Limits	The limits are based on the likely impact on gas odorisation.

Mercaptan sulphur maximum

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Sulphur maximum (mg/m ³)	4.5	5.0	10.0	See section below.	5.0
Excursion duration (minutes)	15	15	30	See section below.	N/A

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when Mitigate and Curtail limits are exceeded.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> Scheduled quantities may be adjusted down. Allowing the Facility Operator to change injection rate to help bring the plant under control. Participants may notify consumers known to be affected by sulphur compounds in the gas. For example: glass manufacturers. Gas retail and distribution businesses may need to prepare for an increase in publicly-reported gas leaks. Mitigation may involve reducing the injection of gas odorant but this should only be the case if the level of mercaptan sulphur is likely to remain relatively constant and reduction is based on the odour level of the mercaptan sulphur compounds.
Curtailement	Mercaptan sulphur is not a cause for curtailing injection on safety grounds by itself unless the total sulphur curtailment level is exceeded.
Reinstatement	The injection of gas can be reinstated once the gas quality is brought to within the Reinstate Level above.

6.2. Temperature Maximum

Description	Prolonged high gas temperatures can have a harmful effect on pipeline steels (stress cracking), valve and regulator seals and components, and corrosion protection coatings.
Limits	The Curtailment limit is based on a short-term excursion from the standard upper design limit. Some sections of pipework may be able to tolerate higher temperatures by design. Any exemptions would need to be assessed on a case-by-case basis and the impact on withdrawal points taken into account.

Temperature maximum

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Temperature maximum	45.0°C	50.0°C	55.0°C	60.0°C	50.0°C
Excursion duration (minutes)	15	15	30	30	N/A

Notifications	When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols. The affected parties will also be notified when Mitigate and Curtail limits are exceeded.
Mitigation	Mitigation steps may include: <ul style="list-style-type: none"> Allowing the Facility Operator to change injection rate to help bring the plant under control.
Curtailment	Once the Curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.
Reinstatement	The injection of gas can be reinstated once the temperature is brought to within the Reinstate Level above.

6.3. Temperature Minimum

Description	<p>Low gas temperatures could have disastrous effects on pipeline steels and other materials. The curtailment limit is based on maintaining pipeline temperature above that likely to cause low temperature embrittlement.</p> <p>A related danger is that at temperatures below 0°C, ice can form on the exterior of pipelines and equipment. Ice on control equipment can result in unstable pressure regulation or operational failure of components.</p> <p>Low temperature also increases the risk of hydrate (ice-like materials) formation inside the pipeline system.</p> <p>Low temperatures also increase the risk of hydrocarbon liquids forming in the pipeline, especially if the hydrocarbon dew point exceeds the gas temperature.</p> <p>Short-term small excursions can be tolerated from a safety perspective provided the average levels are maintained within specification.</p>
Limits	<p>The Curtailment limit is based on the maximum likely brittle/ductile transitions for pipeline steel. Some sections of pipework may be able to tolerate lower temperatures by design and any exemptions would need to be assessed on a case-by-case basis with the impact on withdrawal points downstream taken into account.</p> <p>Lower injection temperatures will only be accepted by AEMO if there are corresponding agreements with the gas producer/ injector to maintain water dew point (at 15,000 kPa) and hydrocarbon dew point (@3,500 kPa) more than 2°C below the minimum injection temperature.</p> <p>Considerations with respect to other gas quality parameters:</p> <ul style="list-style-type: none"> • If the gas injection temperature is below the hydrocarbon dew point (@3,500 kPa) temperature, the injection should be curtailed if the injection pressure is below 6,000 kPa. • If the gas injection temperature is below 2°C (i.e. Notify) and the water content is above 73 mg/m³ (i.e. Notify), the injection should be curtailed if the injection pressure is above 11,000 kPa. • If the gas injection temperature is below 2°C (i.e. Notify) and the water content is above 93 mg/m³ (i.e. Mitigate), the injection should be curtailed if the injection pressure is above 7,000 kPa. • If the gas injection temperature is below -2°C (i.e. Mitigate) and the water content is above 73 mg/m³ (i.e. Notify), the injection should be curtailed if the injection pressure is above 4,500 kPa. The water content impacts are summarised in a table below.

Temperature minimum

	Confirm	Notify	Mitigate	Curtail	Reinstate level
Temperature minimum	3.0°C	2.0°C	-2.0°C	-10.0°C	2.0°C
Excursion duration (minutes)	15	15	1,440 (24 hours)	120 (2 hours)	N/A

Maximum pressure before curtailment for combined water content and temperature excursions. Curtail injection if above indicated pressure:

Temperature	+2 to -2 °c notify limit	-2 to -10 °c mitigate limit
Water content 73 to 93 mg/m ³ notify limit	11,000 kPa	4,500 kPa
Water content 93 to 105 mg/m ³ mitigate limit	7,000 kPa	All pressures

Notifications	<p>When the Notify level has been exceeded continuously for more than 15 minutes (or in total more than 15 minutes in any 30-minute period), affected parties will be notified according to AEMO notification protocols.</p> <p>The affected parties will also be notified when the Mitigate and Curtail limits are breached.</p>
Mitigation	<p>Mitigation steps may include:</p> <ul style="list-style-type: none"> • Allowing the injecting facility to change injection rate to help bring plant under control.
Curtailment	<p>Once the Curtailment limit has been exceeded for the specified time, the injecting party will be instructed to cease injection.</p>
Reinstatement	<p>The injection of gas can be reinstated once the temperature is brought to within the Reinstatement Level above.</p>