

Short title: Gas pipeline commissioning

1. Purpose

This guideline is intended to assist anaesthetists and other clinical practitioners tasked with commissioning medical gas pipelines to comply with AS 2896:2021 - *Medical gas systems – Installation and testing of non-flammable medical gas pipeline systems*. It serves to identify the minimum requirements based on this standard including specifying the personnel, equipment, procedures and documentation required to perform the tests for determining the identity of the gas at the gas terminal outlet (terminal unit) as part of the commissioning procedure and certification of the Medical Gas Pipeline System (MGPS).

It also specifies the documentation necessary for recording and storage of the results of the testing.

2. Scope

Some specific details of this Guideline are applicable to Australia only as New Zealand practice may vary from that detailed in AS 2896:2021.

This document is intended to apply to anaesthetists but is also applicable to other clinical practitioners involved in the testing and certification of the results of operational testing of the gas identity at the terminal units during the commissioning of MGPS.

This guideline is not intended to apply to any additional testing beyond the minimum required by AS 2896:2021. Aspects of pipeline commissioning which do not necessarily involve the anaesthetist such as checking for pipeline contaminants resulting from welding and pressure drop during use following commissioning of new outlets are excluded from this guideline.

It is acknowledged that local jurisdictions may have requirements that exceed those of AS 2896:2021, however that is beyond the scope of this guideline.

3. Introduction

MGPS as conduits for medical gases are a life support system. Integrity of MGPS is essential for delivery of the correct gas at the correct pressure and flow rate to a terminal unit in a medical facility.

Anaesthetists are specialist medical practitioners whose training specifically includes delivery of gas mixtures for patient care. As such, their involvement during testing of MGPS is a critical step where hypoxic mixtures are possible, to ensure that the correct gas is delivered from the correct terminal unit prior to MGPS use for patient care, facilitating patient safety.

Australian Standard: AS 2896:2021 "*Medical gas systems — Installation and testing of non-flammable medical gas pipeline systems*" requires that:

- During the commissioning of a MGPS, a member of the healthcare facility experienced in administration of medical gases to patients ('clinical practitioner') must be present and witness the tests determining that the identification of the medical gas at the terminal unit is correct as designated. Personnel for this role are identified in the standard as either "Healthcare Facility Representative 1 (HFR1)", or "Healthcare Facility Representative 2 (HFR2)".ⁱ Only an anaesthetist can be HFR1.

NOTE There are multiple levels of this role, which are identified in Appendix K of AS 2896:2021

AS 2896:2021 differentiates between Level 1 and Level 2 works.ⁱⁱ Level 1 works are those performed on any part of a MGPS where asphyxiant gases are reticulated or where it supplies special care locations.

NOTE Special care locations are those that service patients who are dependent on specific gases such as oxygen, nitrous oxide, medical air, medical suction, such as anaesthetising areas, post-anaesthesia care units, and coronary care units.

Works on any part of a Level 1 MGPS require the clinical practitioner involved in the tests to be the facility anaesthetist-in-charge or delegated anaesthetist, in the role of HFR1.

4. Background

Undetected cross connections between pipelines of MGPS can result in serious patient harm including death. Cross connection can occur at the time of installation of the MGPS or when modifications or repairs are made to the MGPS.

Testing as per AS 2896:2021 includes a specific 'Cross connection test' of MGPS performed before the supply of the correct gas is connected. Anaesthetists and other clinical practitioners are not required to be involved in this 'Test for cross-connections' (AS 2896:2021 Clause 5.4.8).

Once the medical gas supply to the MGPS is connected, the final commissioning identification of the gas at the terminal unit is another opportunity to confirm correct connection of gas pipelines AS 2896:2021 Clause 5.6.5). It is at this stage that an anaesthetist may be required to be involved as HFR1.

5. Personnel

The healthcare facility must designate a person or persons, competent in medical gas testing and verification of piping systems (Healthcare Facility Representative(s) 'HFR'), to carry out the tests specified in AS 2896:2021. This is often a biomedical engineer for most of these tests.

Final 'operational' verification testing at terminal units requires a clinical practitioner (HFR1 or HFR2) to verify the tests at the terminal unit of gas identity, correct gas-specific connection and labelling.

Anaesthetists, as HFR1 personnel, may be required for this testing of terminal units.ⁱⁱⁱ

The delegated anaesthetist must oversee and witness terminal unit testing to identify the gas, correct gas-specific connection and labelling when:

- Any MGPS works where asphyxiating medical gases such as nitrous oxide and carbon dioxide and/or non-medical gases are piped.
- Works have been undertaken on any part of the MGPS supplying special care locations.

Anaesthetists are not specifically required where only oxygen, medical air and suction are supplied by the MGPS. (This can be undertaken by those persons designated as HFR2 such as an experienced critical care nurse.)

Consultation with relevant biomedical engineering department and anaesthesia colleagues with prior experience in this area should be sought prior to the gas identity tests being undertaken.

6. Equipment

Testing equipment will be provided, managed and maintained (including calibration) by the testing engineer and consists of:

- Oxygen concentration analyser (Figure 1),
- Gas analyser(s) if more than one asphyxiating gas is piped and
- Gas-specific probes, the range of which depends on which medical gases are piped (Figure 2).



Figure 1. Example of gas analyser for testing gas identity at the terminal unit



Figure 2. Example of tool for testing gas-specific connection at the terminal unit

All instruments must have been calibrated within the previous 12 months, or lesser period if recommended by the instrument manufacturer.

Accuracy ratings for pressure gauges must be $\pm 2\%$ of full scale deflection or better. Flow meters must be $\pm 5\%$ of full scale or better.

Oxygen analysers shall be verified at the beginning of testing and further verified every four hours. Other gas analysers shall be verified at the beginning of testing.

All gas specific probes use the same thread. It is the gas-specific sleeve index (see AS 2902) that makes it gas-specific and prevents connection to a wrong terminal outlet.

The following gas-specific probes should be used, depending on which medical gases are piped.

- Oxygen
- Medical air
- Nitrous oxide
- Surgical tool air
- Carbon dioxide
- $<7\%$ CO₂ in oxygen
- Nitrous oxide/oxygen 50/50
- Variable air/oxygen mixtures (rarely reticulated)

- Oxygen/helium mixtures (oxygen $\geq 20\%$) (rarely reticulated)
- Carbon monoxide in air (n.b. this is a NIST fitting)
- Anaesthetic gas scavenging
- Suction

7. Procedure

Before terminal unit verification testing the following will have occurred.

- At completion of construction and initial testing of MGPS by a contractor, pipelines are purged with their designated gases.
- Testing of pressure and flow at terminal units is to be completed before testing of gas identity and gas-specific connection.
- A hard copy of as-installed drawings should be provided to the anaesthetist at the time of gas identity testing,
- The form 'Example of terminal unit test form' (Appendix - Form 1 which corresponds to part of AS 2896:2021 Table G.1) is an example of a form to be used to record the testing. An alternative form to Form 1 may be used.
 - a) Each area/ward should have the room number and bed number/s allocated and marked before any testing is carried out.
 - b) Details at the top of Form 1 are to be entered before commencement of testing in each area.
 - c) Results must be entered on the form at the time of testing.

7.1 Identification of gas at the terminal unit

The gas delivered at each terminal unit must be the correct gas designated for that terminal unit.

Test by verifying the nominal concentration of the gas at each terminal unit with the designated gas analyser(s). For the test to pass, only the correct gas should be detected and at the concentrations in Table 1 (corresponds to AS 2896 Table 5.3).

Where only one asphyxiating gas is piped, such as nitrous oxide or carbon dioxide, or one non-medical gas, an oxygen analyser is used. If more than one asphyxiating gas is piped an oxygen analyser cannot differentiate between the two gases and another method of positive identification must be used such as a gas analyser.

Table 1 Gas analyser limits of reading

Reticulated gas	Oxygen analyser	Nitrous oxide analyser	Carbon dioxide analyser	Helium analyser
Oxygen	≥ 97 %	N/A	N/A	±2 % of nominal oxygen concentration
Medical air	19-23 %	N/A	N/A	< 1 %
Surgical tool air	19-23 %	N/A	N/A	< 1 %
Nitrous oxide	< 1 %	≥ 97 %	< 1 %	N/A
Carbon dioxide	< 1 %	< 1 %	≥ 97 %	N/A
CO ₂ in oxygen (CO ₂ ≤ 7 %) ^a	±2 % of nominal oxygen concentration	< 1 %	±2 % of nominal carbon dioxide concentration	N/A
N ₂ O/O ₂ 50/50	43-57 %	43-57 %	N/A	N/A
Helium and oxygen mixtures (He > 20 %) ^b	N/A	N/A	N/A	±2 % of nominal helium concentration
^a The most commonly used mixture concentration is 5 % CO ₂ in oxygen.				
^b The most commonly used mixture concentration is 28 % helium and oxygen.				

7.2 Correct gas-specific connection and labelling

Each terminal unit must connect only to the correct gas-specific probe and be permanently labelled with the designated gas and the correct colour code for that gas.

The terminal unit should be inspected to confirm that it is correctly labelled for the designated gas, and with the correct colour, and by using the range of gas specific probes that only the correct probe can be connected.

NOTE 1 An uncommissioned terminal unit shall be labelled to indicate it is under test and shall not be used.^{iv}

NOTE 2 In training/simulation areas, medical air shall be used if the gas is other than that indicated on the terminal. If the pipeline system to the terminal unit in a training or simulation area is filled with medical air, the terminal units shall be labelled "For training only — not for patient use".^v

7.3 Results

7.3.1 Identification of gas at the terminal unit

The results of testing for incorrect connection of gas supply will be detection of the correct gas at the terminal unit.

- The gas designated by the terminal unit and no other gas must be detected at the terminal unit.

When the designated gas is detected at the terminal unit as in Table 1 the terminal unit will be deemed to have passed.

7.3.2 Correct gas-specific connection and labelling

The results of testing for incorrect gas-specific connection and labelling involves:

- Confirmation of the correct gas-specific connection and labelling at the terminal unit.
- Confirmation that no other gas-specific connection can be connected at the terminal unit of the gas-specific connection designated by the terminal unit.
- Confirmation of correct permanent label including correct colour identifying the designated gas at the terminal unit

The terminal unit will be deemed to have passed the test when the correct gas-specific connection and labelling is confirmed at the terminal unit.

The results of testing are added to Form 1 or alternative form and the entry is confirmed by the anaesthetist.

If gas from any terminal unit fails to pass the identity test as described in 7.1, the cause of the failure must be determined and the MPGS recommissioned. Recommissioning tests, including verification testing of terminal units for gas identity and gas specific connection, must be carried out on the part affected as if it were an addition to an existing system. If more than 10% of units of a system are affected, all the units then must be retested.

Re/commissioning should take in all downstream gas units. Anaesthesia input may not be required if no gas pipeline has been cut into or no gas-specific connector changed.

Failure of the gas-specific connection and failure of labelling at terminal units as described in 7.2 will require MPGS recommissioning as above.

8. Documentation

The results entered in Form 1 are part of the permanent test record.

The delegated anaesthetist must be noted on Form 1.

A copy of the completed Form 1 must be given to the anaesthetist and held on file by the anaesthetist-in-charge or healthcare facility responsible person.

Anaesthetists involved in certifying the results of operational testing at the terminal units must not sign off testing that was not personally witnessed.

The form used for recording the test results, which may be paper-based or electronic, is likely to include additional information such as pressure, pressure drop and flow at each terminal unit. Anaesthetists are not specifically required to be involved in these tests and must not sign off these results if not personally witnessed or if the anaesthetist is not confident in the testing procedure for these other tests.

9. Use of terminal units following works involving pipelines and terminal units

Anaesthetists should be aware that terminal units in areas with nitrous oxide, carbon dioxide and other asphyxiating gases should not be used following work involving pipeline cut-ins or replacement of terminal units on the MGPS, until a formal recommissioning process has been completed. Confirmation of recommissioning may be sought from the delegated healthcare facility responsible person.

This document is accompanied by a background paper (PG66(A)BP) which provides more detailed information regarding the rationale and interpretation of the Guideline.

Appendix Form 1^{vi}

Example of terminal unit test form
Gas identity and specific gas connector

Health Care Facility.....
Job number.....
Area/ward.....
Page.....

Test date and time

Room no.	Bed no.	Terminal unit type (intended gas)	Oxygen concentration		Gas identity by alternative gas monitor		SIS outlet connection verification		Pass/fail	Comments
			Result	Witness	Result	Witness	Result	Witness		

Inspected by (Installer) Name

Witnessed by (Builder/contractor) Name

Witnessed by (Client, health care facility) Name

NOTE 1: Each area/ward should have the room number(s) and bed number(s) allocated and marked before any testing is carried out.

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Promulgated: 2021
Reviewed:
Current document: October 2021

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ⁱ AS 2896:2021 Annex K; HFR definitions

ⁱⁱ AS 2896:2021 Clauses 1.4.24 and 1.4.25

Level 1 works - works performed on part of a MGPS where asphyxiant gases, are reticulated, or any part of a MGPS where there are special care locations.

Level 2 works - works performed on part of a MGPS where the only reticulated gas services are a combination of either oxygen, medical air, surgical tool air or suction, and where there are no special care locations.

ⁱⁱⁱ AS 2896:2021 Clauses 5.6.5.2

^{iv} AS 2896:2021 Clause 5.3

^v AS 2896:2021 Clause 3.6.9

^{vi} AS 2896:2021 Corresponds to part of Table G.1