Nitrous Oxide Medical Gas Pipeline

Leak Test Protocol

For hospitals with active nitrous oxide manifolds and pipelines

Green Theatres Network

Based on the protocol developed by J.Anderson, Department of Anaesthesia, Pain and Perioperative Medicine, Fiona Stanley and Fremantle Hospitals, 2023.1

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Background

N_2O (Nitrous Oxide) is a schedule 4 drug used for anaesthesia, sedation and analgesia. It is a potent greenhouse gas and occupational hazard. N_2O has a global warming potential (GWP) that is approximately 300 times greater than that of carbon dioxide (CO2) over a 100-year time horizon. This means that each kilogram of nitrous oxide emitted into the atmosphere has the same effect on climate change as 300 kilograms of CO2. N_2O contributes around 2% of the NHS carbon footprint and 75% of the anaesthetic gas carbon emissions.

Leakage of N_2O from defects in medical gas pipelines accounts for >90% of N2O consumption at some hospital sites. Current Australian standards require regular testing of pipeline outlets for leaks but not the entirety (or zones of) of the system. Sites which have passed recommended tests have subsequently been demonstrated to have major leaks (eg: Sir Charles Gairdner, Western Australia 2022). This protocol outlines a more comprehensive pipeline pressure test, similar to that required by Australian Standard AS2896-2021 for commissioning of new pipelines.

This test protocol aims to detect leaks in the nitrous oxide pipeline-manifold system of the hospital whilst there is zero clinical consumption of the gas.

Test Objectives	Key Performance Indicators, Policy, Guideline
Measure initial pressure in N2O pipeline (manifold connected)	Australian Standard AS 2896-2021 Target: 415kPa (acceptable range 375-460kPa)
Measure pipeline pressure change once manifold isolated, over 4 hour period of zero-demand	KPI: No change except for that explained by temperature. Policy: "Total system pressure test" AS2896 – clause 5.5.2
Measure ambient outdoor temperature to account for any pressure changes	PV=nRT (Ideal Gas Law).
Ensure appropriate control of schedule 4 medication	Australian National Safety and Quality Health Service (NSQHS) Standards – Medication Safety Standard, Action 4.14 Safe and Secure storage and distribution of medicines
Minimise unnecessary greenhouse gas pollution	SMHS Sustainability Framework, WA Health Sustainability Framework, Australian New Zealand College of Anaesthetists Professional Statement 64(G) Position statement on environmental sustainability in anaesthesia and pain medicine practice 2019

Stakeholders

Testing the institution's medical gas pipelines in a 'zero-consumption' window requires extensive consultation and involvement of a wide range of hospital stakeholders. Suggested stakeholders are listed below. A report on the N_2O pipeline test should be made available to these individuals.

Stakeholders	Name, Role, Contact
Hospital Executive Director of Clinical Services	
Head of Department: Anaesthesia Nurse Unit Manager: Theatres Head of Department: Obstetrics Nurse Unit Manager: Labour Ward Head of Department: Emergency Nurse Unit Manager: Emergency HoD and NUM of other areas using piped N_2O	
Pharmacy Lead	
Facilities Management / Engineering	

N_2O Pipeline Map: Patient Needs Assessment

Hospital Engineers should be able to supply a map of nitrous oxide pipeline and outlets in your institution. It is important to understand the time of day N_2O usage needs of all areas in the hospital. Relevant staff on shift need thorough communication regarding test.

☐ Relevant clinical staff aware that no piped N_2O is to be used during the test window.
☐ Cylinder N_2O or Entonox available in areas where N_2O must be available, for example labour ward.

Schedule Requirements

The test should be conducted during a period of 'low demand' for piped N_2O, for example at the end of business day after elective surgery has completed. Eg: 1800-2200hrs.

Planned Test Window: Date:_____ Start time: _____ End Time: _____ (four hours recommended)

Location Requirements

Access to the following locations should be ensured prior to and during the test window. Staff in these areas must be aware of test.

☐ Hospital Gas Room (N_2O Manifold location)

☐ Operating Theatre with Anaesthetic Machine

☐ Areas of hospital with N_2O outlets: to ensure zero-consumption.

Test Team

Role	Task	Name	Location	Contact Number During Test
Test Lead	Usually a senior anaesthetist. Responsible for test safety, overall oversight, liaising with clinical areas and engineering		Gas Room and Theatres	
Data recorder	A staff member familiar with test anaesthetic machine. Records pressure reading from anaesthetic machine at 15 minute intervals.		Operating Theatre	
Shift Engineer	Responsible for access to gas room. Management of any low pressure alarms or isolation of parts of medical gas pipeline. Ensure safety of medical gas system.		Gas Room and roaming	
Duty Anaesthetist	Liaises with Test Lead in case of clinical urgency to turn back on the piped nitrous supply		Theatres	
Theatre Coordinator	Kept informed by Test Lead re: N_2O gas pipeline status.		Theatres	
Other Area Coordinator (eg: Labour Suite)	Kept informed by Test Lead re: N_2O gas pipeline status.			

Equipment Requirements

☐ Anaesthetic Machine with digital readout of N_2O pipeline pressure.
☐ Temperature gauge to record temperature in gas room.
☐ Laptop to record 15 minutely pipeline pressure readings and temperature in spreadsheet
☐ Access keys/cards to gas room/manifold, theatres and other relevant clinical areas.
☐ Lead pencil for marking analogue N2O pipeline pressure dial in gas room

Communication and pre-test safety check list

Complete?	Check	Person Responsible	Due Date/Time	Comments
☐	Global email sent to all clinical staff	Test Lead	2 working days prior	If required / relevant
☐	Switchboard Notification	Test Lead	2hr pre-test	in case reports of low pressure alarms are communicated to switch
☐	Pre-Brief Test Team	Test Lead	1hr pre-test	Set up messaging group to relay readings / test status
☐	Walkaround and safety check: Theatre Nurse Coordinator, Duty Anaesthetist, Labour Suite Coordinator,	Test Lead	15 mins pre-test	Low pressure alarms may be heard.
☐	Baseline N_2O pipeline pressure reading at gas room gauge and anaesthetic machine	Data recorder & Shift Engineer	Prior test commencing	Record in spreadsheet. Mark analogue dial with lead pencil to detect movement. Should be around 415kPa
☐	Patient safety risks controlled. All relevant staff aware. **Good to go with test.**	Test Lead	Prior test commencing.	Advise team. Commence Test.

Leak Test Actions

Isolation of Manifold

The Nitrous Oxide Cylinders should be isolated from the gas pipeline by either
1. Turning off each of the nitrous cylinders in manifold or
2. Turning off a valve between the manifold and pipeline.

Option 1 is preferred as it will identify any leaks in connections between cylinders, manifold and pipeline.

When testing only a zone of the hospital, zone isolation valves can be used to 'isolate' a section of pipeline from the manifold. The Anaesthetic Machine measuring pipeline pressure must be in the 'isolated' section of pipeline.

The test pipeline should be isolated for 4 hours.

Measurements

Measurements of the pipeline pressure should be recorded *before isolation* of manifold and then periodically once pipeline is isolated (eg: 15 minutely) at the Anaesthetic machine (digital) and any gauges in the gas room (usually analogue). Ambient temperature in gas room should be recorded at the same intervals.

A leak is confirmed if any pressure drop occurs, which cannot be explained by drop in ambient temperature. PV = nRT thus changes in temperature (has to be in kelvin) are directly proportional to changes in pressure (Pa) for a uniform pipeline volume and quantity (assumed, if zero demand). $\mathbf{P_2 = P_1 \times T_2 / T_1}$ Remember to use Kelvin temperature where $T_{(K)} = T_{(°C)} + 273$.
Pipeline low pressure alarms should be activated if pressure drops below 20%, as per AS2896.

Example Data collection table

Time	Gas Room N_2O Pressure	Anaesthetic Machine N_2O Pressure	Ambient Temperature
1800 hrs	415 kPa	417kPa	27.1˚C
1815 hrs	415 kPa	417kPa	26.5˚C
1830 hrs	…	…	… for four hours

End of test check

If no leak by 4 hours: turn on N_2O flow meter on anaesthetic machine to 10 litres/ minute to confirm leak is detected by measurement gauges and that no cylinders have remained 'connected' to pipeline. Once this drop in pressure is detected, test can end and cylinders can be reconnected to pipeline.

Confirm Gas Supply Servicable

Once N2O manifold reconnected (opened) to pipeline, confirm that N2O flow from anaesthetic machine does not drop pipeline pressure and that pipeline pressure is starting pressure (~415kPa).

Reporting

Outcomes of test, including the presence of any leak, should be reported to Stakeholders outlined above.
Urgent remediation or decommissioning of pipeline is required if a leak of this polluting, schedule 4 drug is detected.

References

Australian Standard 2896:2021 https://store.standards.org.au/product/as-2896-2021

Improvements to Protocol

If you have any suggestions for improvements to this protocol, please email nitrous@greentheatres.online