Figure 5.3 — Test device for terminal unit flow and pressure measurement

Figure 5.4 — Test device for flow and pressure measurement of medical suction and scavenge

5.6 Filling system with the working gas and final commissioning

5.6.1 General

When all MGPS have been tested in accordance with Clause 5.5, the source of test gas shall be disconnected and the working gas source connected to each respective system.

5.6.2 Filling with the working gas

Where the working gas is an asphyxiant gas and a gas-specific analyser is not available for identity testing, an initial purge using medical air or oxygen shall be undertaken through these systems. Terminal units shall be tested with an oxygen analyser to ensure no pockets of test gas are present prior to filling with the working gas.

All systems shall be purged with their own working gas for a sufficient time to fill the system with that gas. Particular attention shall be paid to purging each terminal unit to ensure no pockets of the non-working gas remain, beginning with the terminal unit closest to the source and ending at the most remote terminal unit.

If a MGPS remains unused for a prolonged period of time after commissioning, a second purge with the working gas should be undertaken just prior to its use on patients.

NOTE When purging with any other gas than medical air, consideration should be given to releasing large volumes of those gases into a local area. AS/NZS 2865 provides guidance on confined spaces and AS 5034 gives guidance for non-naturally ventilated areas.

5.6.3 Test of source of supply system

All functions of the source of supply system, whether they be a cryogenic liquid vessel, gas cylinder manifold, compressor or suction pump, shall be tested in normal and emergency operating conditions. Particular attention shall be paid to the following:

(a) Operation of all valves and pressure gauges on manifolds. Operation of the automatic change-over shall be tested in both directions.

(b) Operation of any electric or pneumatic valves.

(c) Function of electrical circuits for operation, insulation resistance and effectiveness of earthing.

(d) A check to ascertain that each item of plant is capable of operating to its maximum designed performance.

(e) A check of all compressors and suction pumps to the manufacturer's specifications, paying particular attention to pressure relief valves, thermostats and other plant protection devices.

(f) A check of all gas-specific SIS or NIST connections to verify they are correct, using a gas-specific test device.

Testing of the cryogenic liquid vessel system may need to be undertaken in conjunction with the gas supplier representative (GSR).

Other tests shall be undertaken by the installer and contractor and HCF3 personnel, or HCF3 personnel's appointed representatives.

5.6.4 Checks on operation of alarm systems

All alarms connected to the MGPS shall be tested to ensure they function in accordance with Section 3.2.

This test shall be undertaken by the installer, contractor and HCF3 personnel or their appointed representatives.

NOTE 1 It may be convenient to carry out these tests at the same time as those required by Clause 5.6.3.

NOTE 2 The interface between the alarm system and the BMS should be verified where applicable.

5.6.5 Test for gas identity

5.6.5.1 Preparation for testing

After filling with the working gas, as required in Clause 5.6.2, tests shall be carried out as specified in Clause 5.6.5.2. A hard copy of as installed drawings should be provided at the time of gas identity testing (see Clause 5.8.1).

5.6.5.2 Requirements for testing

Each terminal unit on each system shall be checked to verify the nominal concentration of the gas. Results of this test shall form part of the permanent test record (see Clause 5.7).

If more than one asphyxiant gas is reticulated, e.g. carbon dioxide and nitrous oxide, an oxygen analyser alone cannot differentiate between the two gases. Guidelines for testing facilities with various combinations of reticulated gases are detailed below, and the test results shall satisfy the concentration limits as detailed in Table 5.3.

(a) If a facility has reticulation systems running in parallel for only the following gases, an oxygen analyser alone is sufficient for completing the gas identity test:

(i) Oxygen.

(ii) Medical air.

(iii) Surgical tool air.

(iv) Carbon dioxide or nitrous oxide but not both CO_2 in oxygen ($CO_2 \leq 7$ %); and N_2O/O_2 50/50.

(b) If a facility has reticulation systems running in parallel for more than one of the following gases, an oxygen analyser and either a nitrous oxide or a carbon dioxide analyser shall be used to complete the gas identity test:

(i) Oxygen.

(ii) Medical air.

(iii) Surgical tool air.

(iv) Nitrous oxide.

(v) Carbon dioxide.

(vi) CO_2 in oxygen ($CO_2 \leq 7$ %).

(vii) N_2O/O_2 50/50.

(c) If a facility also reticulates helium and oxygen mixtures, a helium analyser is required to complete the gas identity test, as well as gas analysers as applicable in accordance with (a) or (b). The helium and oxygen mixture terminal units as well as any medical air and surgical tool air terminal unit shall be tested using the helium analyser.

(d) If a facility reticulates an asphyxiant gas other than nitrous oxide, carbon dioxide or helium/oxygen mixtures, a risk assessment on the testing method shall be conducted in accordance with AS/NZS ISO 31000 and documented. The selected method of testing shall be retained as part of the permanent test record.

Table 5.3 — Gas analyser limits of readings

Reticulated Gas	Oxygen Analyser	Nitrous oxide Analyser[c]	Carbon dioxide Analyser[c]	Helium Analyser[d]
Oxygen	≥ 97 %	N/A	N/A	N/A
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_2O/O_2 50/50	43–57 %	43–57 %	N/A	N/A
Helium /oxygen mixtures[b]	±2 % of nominal oxygen concentration	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 in oxygen.

[c] In accordance with Clause 5.6.5.2(b)

[d] In accordance with Clause 5.6.5.2(c)

NOTE: All values in Table 5.3 are % volume.

Oxygen analysers shall be calibrated in accordance with the manufacturer's instructions and verified at the beginning of testing, and further verifed every four hours. Other gas analysers shall be calibrated in accordance with the manufacturer's instructions and verified at the beginning of testing.

When testing terminal units of the same gas, sufficient time shall be allowed between testing consecutive terminal units to see a visual reading response from the analyser (e.g. the gas concentration reading falls after completion of testing of the first terminal unit then rises on testing of the next terminal unit.

For Level 1 works, this test shall be undertaken by the installer, contractor and HCF1 personnel or their appointed representatives.

For Level 2 works, this test shall be undertaken by the installer, contractor and HCF2 personnel or their appointed representatives.

5.6.5.3 Failures during identity tests

If gas from any terminal unit fails to pass the identity test, the cause of the failure shall be determined, fixed and the system recommissioned.

5.6.5.4 Check for correct gas-specific connection

Each SIS terminal unit and SIS auxiliary/emergency supply connection shall be checked to verify that the gas-specific indexing is correct, using a test piece which ensures gas specificity in accordance with Clause 3.6.2. Each NIST connection for any services modules shall be checked to verify that the gas-specific indexing is correct, using a gas-specific sleeve index testing tool or other test piece which ensures gas specificity in accordance with Clause 3.6.2.

For Level 1 works, this check shall be undertaken by the installer and contractor and HCF1 personnel.

For Level 2 works, this check shall be undertaken by the installer and contractor and HCF2 personnel.

5.7 Certification of systems

The following documentation shall be provided by the installer to the organization that contracted their services prior to the MGPS being used on patients:

(a) A copy of the commissioning plan (see Appendix M).

(b) A copy of test certificate results produced during the commissioning of the MGPS. The test certificates shall contain clear details of services and areas tested.

(c) An operation manual giving clear instructions on the use of the MGPS and the key pieces of equipment in the MGPS.

(d) Product literature on essential pieces of equipment used in the MGPS.

(e) Any necessary handover instructions.

(f) A final certificate of conformance for the works done which shall include the following:

  (i) Name of Healthcare Facility.

  (ii) Zone or area identification within Healthcare Facility where applicable.

  (ii) Company name of the installer or contractor.

  (iii) Reference to this Standard, i.e. AS 2896:2021.

  (iv) Conformance with tests outlined in Clause 5.1.

  (v) Date of certification.

(g) Signature of installer's representative and printed name in full.

NOTE The forms provided in Appendix G may be reproduced for the purposes of recording results of tests made for certification, as required by this Clause.

This documentation should be obtained and retained by the healthcare facility operator to form part of its permanent record.

The installer or contractor shall take responsibility for the certificate of conformance and obtain acceptance from other roles in accordance with Appendix K.

The certification documentation may be either a paper hard copy version or an electronic version. The installer or contractor should keep a copy of all documentation for their own records.

5.8 As-installed drawings

5.8.1 General

A separate set of as-installed drawings shall be maintained during construction, and kept up-to-date as modifications are made. These electronic drawings may be in CAD or BIM format, and also PDF copies or the equivalent made.

5.8.2 Marking

Complete as-installed drawings specified in Clause 5.8.1 shall be presented to the healthcare facility as a set of permanent reproducible drawings marked "As-installed for MGPS" and dated. These shall be part of the facility's permanent records.

5.8.3 Updating

As-installed drawings forming part of the permanent record as per Clause 5.8.2 shall be brought up-to-date by the installer or contractor. These shall record any modifications to the pipeline system made subsequent to the transfer of drawings to the healthcare facility, including the date of such modifications.

5.8.4 Supplementary master drawing

When the original MGPS has been enlarged to a substantial extent, the as-installed drawings specified in Clause 5.8.3 shall be supplemented by a new master drawing which correlates all modifications with the original installation, and include the date of these modifications.

NOTE Because of cost, this requirement should be specified by the healthcare facility in the original modification proposals.

5.8.5 Emergency reference

A simplified diagram of the MGPS should be mounted in a convenient location for maintenance and other staff in the case of an emergency. It should show key features of the system to assist in deciding the effect of failure or shutdown of parts of the system. Drawings should be to a suitable scale, legible and durable for the purpose of assisting in deciding the effect of failure or shutdown of parts of the system.

Section 6 Maintenance

6.1 General

This Section sets out requirements for testing, observing and recording the condition and performance of a MGPS, with the objective of ensuring that it should continue to conform with the requirements of this Standard, and to function reliably.

MGPS shall only be maintained by persons suitably trained in the maintenance of medical gas pipelines. The healthcare facility shall ensure that outside contractors and persons within the healthcare facility engaging in the maintenance of MGPS activities are competent and trained to do so. Training for such persons engaging in this work shall be provided by the equipment suppliers or manufacturer.

The tests and inspections of a MGPS, as specified below, shall be carried out in a systematic manner so that recommended intervals can be reasonably adhered to.

NOTE Manufacturer's instructions may be referred to as the primary source of information for maintenance requirements.

All tests and observations shall be recorded in a permanent log and all abnormalities reported and rectified as soon as possible.

Records of all changes made to the MGPS shall be kept by the healthcare facility.

6.2 Safety and warning devices

The following shall be tested for correct operation:

(a) *Pipeline pressure relief valves* — Visual inspections for signs of damage or tampering shall be carried out at intervals of not more than 12 months. Testing or replacement shall be carried out at a frequency according to the manufacturer's instructions or at intervals not exceeding 5 years, whichever period is the lesser.

(b) *Alarm systems on the MGPS* — Gas alarm systems, including activation of pressure switches, shall be tested at intervals of not more than 12 months. Existing alarm panels which are not Extra Low Voltage (ELV) shall not be used. Existing alarm panels which do not recognize open or short circuits or do not have alphanumeric display or labelling should not be used.

6.3 Source of supply

6.3.1 Verification of correct operation

A source of supply, whether it is a cryogenic liquid system, compressed gas cylinder manifold compressor, or suction pump, shall be verified for correct operation at intervals of not more than 12 months or in accordance with the manufacturer's instructions, whichever is less. Verification shall also ensure that no unauthorized modifications have been made to the system.

Fixed cryogenic liquid supply sources shall be maintained by the gas suppliers. If the gas control equipment connected to the cryogenic system is owned by the gas supplier it shall be maintained by the gas supplier. If the gas control equipment is owned by the healthcare facility, the healthcare facility shall maintain the equipment.

6.3.2 Inspection of manifold system

Manifold systems shall be tested and inspected at intervals of not greater than 12 months or in accordance with the manufacturer's instructions, whichever is less, for leaks and malfunction as follows:

(a) Test pressure settings of the pressure regulators.

(b) Test pressure regulators for external leaks.

(c) Smooth transfer of gas with pressure reduction not including emergency supply cylinder manifolds for cryogenic sources of supply.

(d) Inspect cylinder and pack extension leads for flexibility, metal fatigue and thread damage to cylinder and pack connections.

NOTE 1 The manufacturer of cylinder leads should provide recommendations for their replacement frequency.

(e) Inspect manifold connections for external leaks.

(f) Cylinder-connecting leads manufactured from copper shall be carefully inspected for work hardening and, where affected, the leads shall be replaced. All damaged leads shall be replaced immediately.

The function of the manifold shall be verified at the completion of servicing.

NOTE 2 The verification of the function of the manifold does not require a gas identity test of the MGPS.

6.3.3 Checking of manifolds

All gas cylinder manifolds shall be checked at least weekly when in use to ensure that —

(a) cylinders have been changed where necessary;

(b) the manifold change-over system is working;

(c) there is no excessive frosting or condensation; and

NOTE If frosting or condensation occurs on primary pressure regulators, it is likely to be on nitrous oxide or carbon dioxide cylinders, or on nitrous oxide/oxygen mixture cylinders, and denotes an excessive demand, either through leaks or because of inadequacy of the supply plant. Possible excessive demand should be reviewed with the manifold manufacturer. Such frosting may indicate a need for heaters.

(d) there are no obvious leaks or faults on the equipment.

6.3.4 Inspection of air compressors and suction pump system

6.3.4.1 General checking

Air compressors and suction pumps shall be serviced and maintained at a frequency according to the manufacturer's instructions or, where no instructions are given, a period of no greater than 12 months.

6.3.4.2 Specific items for checking

The air compressor and suction pump system shall be inspected in accordance with the manufacturer's instructions, including (where applicable) the following:

(a) Automatic alternating controls for proper function.

(b) Pressure of suction switch for correct lag pump operation.

(c) Frequency of starts and duration of run period and comparison with previous records.

(d) Cut-in and cut-out pressures.

(e) Adequacy of water flow to after-cooler, if relevant.

(f) Automatic drain on receivers and drier, and on exhaust system on suction plant.

(g) Operation of drier.

(h) Oil level on oil-lubricated plant.

(i) Air filters or strainers (or both).

(j) Correct supply rate of water cooling system to equipment or seal water if installed, and correct temperatures.

(k) Filters and reducing valves for correct functioning.

6.4 Purity of medical air

6.4.1 General

If medical or surgical tool air is produced from an on-site compressor system, testing shall be conducted. The testing program shall be based on the requirements defined in Clauses 6.4.2 and 6.4.3.

6.4.2 Medical air

For medical air the testing program shall be based on the following requirements:

(a) *Testing for system validation* — Testing using analytical test methods shall be performed as part of the initial commissioning of the on-site medical air compressor system, after major system maintenance or modification, or after a prolonged period of downtime. The on-site medical air compressor system shall not commence operation until all contaminants are within the nominated tolerance levels specified in AS 2568.

(b) *Testing for quality control* — To ensure the ongoing purity of medical air, a combination of continuous and periodic monitoring shall be performed at least annually. Gas detector tubes may be used for this purpose.

Where test results exceed contaminant tolerance levels specified in AS 2568, the system shall be corrected and retested using analytical test methods. During this time, mitigation measures reflective of any risks identified in a risk assessment conducted in accordance with ISO 31000 shall be put in place to ensure patient safety.

The system shall be retested again at 3 months to confirm conformance. Then annual testing may be resumed. Gas detector tubes may be used for this purpose.

Gas constituents such as oxygen, carbon dioxide, carbon monoxide and those listed in AS 2568 may also be continuously monitored.

Continuous gas monitoring shall be serviced and maintained in accordance with the manufacturer's instructions.

NOTE 1 The decision to continuously monitor certain gas constituents will be determined by local conditions. Where a change in such conditions may adversely impact the quality of ambient air being drawn into or passing through the compressor, then continuous monitoring should be considered. For example, continuous monitoring of carbon monoxide may be necessary if the air intake to the compressor is in close proximity to high vehicle traffic. Vehicle exhaust emissions may contain very high levels of carbon dioxide.

NOTE 2 Where continuous monitoring of gas constituents is in place, the associated alarms should be relayed to a gas alarm panel in a continuously monitored area. Consideration should be given to the set-points of these alarms to mitigate nuisance alarms and also allow for early detection of contaminants.

NOTE 3 Other testing frequencies may be used as determined by a documented risk assessment conducted in accordance with AS/NZS ISO 31000, and taking into consideration any relevant legislative requirements or industry guidelines.

6.4.3 Surgical tool air

For surgical tool air the testing program shall be based on the following requirements:

(a) *Testing for system validation* — Testing using analytical test methods shall be performed as part of the initial commissioning of the on-site surgical tool air compressor system, after major system maintenance or modification, or after a prolonged period of downtime. The on-site surgical tool air compressor system shall not commence operation until the purity level is in accordance with that specified in Clause 2.11.

(b) *Testing for quality control* — To ensure the ongoing purity of surgical tool air, testing shall be performed at least annually in accordance with Clause 2.11. In addition to the annual tests, gas constituents including water vapour shall be tested at least quarterly or continuously monitored.

NOTE 1 The decision to continuously monitor certain gas constituents will be determined by local conditions. Where a change in such conditions may adversely impact the quality of ambient air being drawn into or passing through the compressor, then continuous monitoring should be considered.

NOTE 2 Testing may be performed using gas detector tubes.

NOTE 3 Where continuous monitoring of gas constituents is in place, the associated alarms should be relayed to a gas alarm panel in a continuously monitored area. Consideration should be given to the set-points of these alarms to mitigate nuisance alarms and also allow for early detection of contaminants.

Where test results or continuous monitoring readings exceed purity levels with that specified in Clause 2.11, the system shall be corrected and retested using analytical test methods. During this time, mitigation measures reflective of any risks identified in a risk assessment conducted in accordance with ISO 31000 shall be put in place to ensure patient safety.

NOTE 4 Other testing frequencies may be used as determined by a documented risk assessment conducted in accordance with AS/NZS ISO 31000.

6.5 Maintenance of terminal units

Inspection of terminal units shall be carried out at regular intervals not more than 2-yearly. Inspection shall be carried out as follows:

(a) Check for leakage in main valve and replace seals and o-rings where necessary or at a period of no longer than 4 years.

(b) Check condition of male connecting thread on sleeve index type units, and replace if worn or damaged.

(c) Check for presence and condition of gas-specific indexing components to ensure it is not possible to connect incorrect hose or equipment.

(d) Check that flow and pressure conforms with Table 5.1. The selected test pressure shall lie within the range specified in Table 5.1.

Any terminal units not conforming with this Standard discovered during service or maintenance inspection shall be tagged and replaced.

NOTE This requirement operates retrospectively due to the risk to health and safety that non-conforming terminal units represent.

Appropriate records should be retained using Table G.1.

6.6 Pressure gauges and pressure switches

All pressure switches within the pipeline system shall be checked for performance utilizing their associated gauge at least every 12 months.