BRITISH STANDARD

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Medical gas pipeline systems —

Part 3: Pipelines for compressed medical gases and vacuum

The European Standard EN 737-3:1998 has the status of a British Standard

ICS 11.040.10

National foreword

This British Standard is the official English language version of EN 737-3:1998 incorporating Amendment EN737-3:1998/A1:1999.

The UK participation in its preparation was entrusted by Technical Committee CH/44, Anaesthetic machines, breathing attachments, medical gas pipeline systems and hose assemblies, to Subcommittee CH/44/2, Medical gas supply systems, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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This European Standard was approved by CEN on 4 September 1998.

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 215, Respiratory and anaesthetic equipment, the Secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1999, and conflicting national standards shall be withdrawn at the latest by April 1999.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative annex ZA, which is an integral part of this standard.

EN 737 consists of the following parts under the general title "*Medical gas pipeline systems*":

— *Part 1: Terminal units for compressed medical gases and vacuum*;

— *Part 2: Anaesthetic gas scavenging disposal systems*;

— *Part 3: Pipelines for compressed medical gases and vacuum*;

— *Part 4: Terminal units for anaesthetic gas scavenging systems*;

— *Part 6: Dimensions of probes for terminal units for compressed medical gases and vacuum* (in preparation).

Annexes A, B, C, D, E, F, G, H, J, K, L, and ZA are given for information only.

Annex L contains rationale statements for this part of this European Standard. The clause and subclauses which have corresponding rationale statements are marked with **R** after their number.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

Foreword to EN 737-3:1998/A1:1999

This Amendment EN 737-3:1998/A1:1999 to EN 737-3:1998 has been prepared by Technical Committee CEN/TC 215, Respiratory and anaesthetic equipment, the Secretariat of which is held by BSI.

This Amendment to the European Standard EN 737-3:1998 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2000, and conflicting national standards shall be withdrawn at the latest by June 2000.

This Amendment to the European Standard EN 737-3:1998 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

The purposes of this amendment are:

— to correct the range of materials (**4.3.8**);

— to delete requirements for air for breathing and air for driving surgical tools that were in conflict with the European Pharmacopoeia (**5.4.1.4/5**);

— to correct errors in pressures and to accommodate pressures used in some member states (Tables 1 and 3).

Introduction

This European Standard specifies basic requirements for compressed medical gases and vacuum pipeline systems.

This European Standard seeks to ensure that medical gas pipelines contain only the specific gas intended to be supplied. For this reason gas-specific components are used for terminal units and for other connectors which are intended to be used by the operator. In addition, each system is tested and certified to contain only the specific gas.

These specifications and procedures are undermined by the lack of European Standards for gas-specific connections on gas and non-cryogenic liquid cylinders and mobile and stationary cryogenic vessels. Until European Standards for these items are published and implemented, the safety of patients depends upon different National Standards together with manufacturer's specifications.

1 Scope

1.1 This European Standard specifies basic requirements for installation, function, performance, documentation, testing and commissioning of compressed medical gases and vacuum pipeline systems to ensure patient safety by continuous delivery of the correct gas from the pipeline system.

It includes basic requirements for the sources of supply, distribution system, control, monitoring and alarm systems, and for non-interchangeability between components of different gas systems.

The objective of this part of this European Standard is to ensure the following:

a) design of equipment to ensure non-interchangeability between different gas systems;

b) provision of reserve supplies of gas and reserve plant in order to ensure continuous supply;

c) use of correct materials, and their cleanliness;

d) correct installation;

e) control, monitoring and alarm systems;

f) marking of the pipeline system;

g) testing, commissioning and certification;

e) purity of the gases delivered by the system.

The scope of this European Standard does not include the provision of gas-specific connectors for mobile and stationary cryogenic vessels and transport vehicles, nor for the inlet/outlet of non-cryogenic liquid and gas cylinders. Such gas-specific connectors, however, are essential to ensure that only the correct gas can be used for the gas supply to the patient.

1.2 This European Standard applies only to pipeline systems for the following medical gases:

— oxygen;
— nitrous oxide;
— air for breathing;
— carbon dioxide;
— oxygen/nitrous oxide mixture [50:50 (% *V/V*)];
— air for driving surgical tools;
— nitrogen for driving surgical tools

and to pipeline systems for:

— vacuum.

1.3 This European Standard does not apply to terminal units, dimensions of probes, hose assemblies and colour coding for medical gases which are specified in other parts of this European Standard (EN 737-1 and prEN 737-6:1996) and in other European Standards (EN 739).

1.4 This European Standard does not apply to pipeline systems supplied by oxygen concentrators which comply with ISO 10083.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 143:1990, *Respiratory protective devices — Particle filters — Requirements, testing, marking.*
EN 286-1, *Simple unfired pressure vessels designed to contain air or nitrogen — Part 1: Pressure vessel for general purposes.*
EN 475, *Medical devices — Electrically-generated alarm signals.*
EN 737-1, *Medical gas pipeline systems — Part 1: — Terminal units for compressed medical gases and vacuum.*
EN 738-2:1998, *Pressure regulators for use with medical gases — Part 2: —Manifold and line pressure regulators.*
EN 739, *Low-pressure hose assemblies for use with medical gases.*
EN 793, *Particular requirements for safety of medical supply units.*
EN 850, *Transportable gas cylinders — Pin-index yoke-type valve outlet connections for medical use.*
EN 1441, *Medical devices — Risk analysis.*
EN ISO 9001, *Quality systems — Model for quality assurance in design/development, production, installation and servicing* (ISO 9001:1994).
EN 46001, *Quality systems — Medical devices — Particular requirements for the application of EN ISO 9001.*
HD 384, *Electrical installations of buildings.*
ISO 3746, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane.*
ISO 5145, *Cylinder valve outlets for gases and gas mixtures — Selection and dimensioning.*

3 Definitions

For the purposes of this standard the following definitions apply.

3.1
air compressor system
source of supply with compressor(s) designed to provide air for breathing and/or air for driving surgical tools

3.2
air for breathing
natural or synthetic mixture mainly composed of nitrogen and oxygen in specified proportions [approximately 21 % oxygen and 79 % nitrogen (*V/V*)] with defined limits for the concentration of contaminants, supplied by a pipeline system and intended for administration to patients

3.3
air for driving surgical tools
natural or synthetic mixture mainly composed of nitrogen and oxygen in specified proportions [approximately 21 % oxygen and 79 % nitrogen (*V/V*)] with defined limits for the concentration of contaminants, supplied by a pipeline system and intended for driving surgical tools

3.4
commissioning
proof of function to verify that the agreed system specification is met and is accepted by the user or his representative

3.5
control equipment
items necessary to maintain the gas supply at a set pressure within the pipeline distribution system, such as pressure regulators, relief valves, alarm initiators and manual and automatic valves

3.6
cryogenic liquid system
source of supply containing liquified gas stored under cryogenic conditions

3.7
cylinder bundle
pack or pallet of cylinders linked together with a single connector for filling and emptying

3.8
diversity factor
factor which represents the maximum proportion of terminal units in a defined clinical area which will be used at the same time at flows defined in agreement with the hospital management

3.9
double-stage pipeline distribution system
pipeline distribution system in which gas is initially distributed from the source of supply at a higher pressure than the nominal distribution pressure; this higher pressure is then reduced by additional line pressure regulators

3.10
emergency alarm
visual and auditory alarm to indicate to technical and clinical staff that the supply is outside normal operating limits

3.11
gas-specific
having characteristics which prevent interchangeability, thereby allowing assignment to one gas or vacuum service only

3.12
gas-specific connector
connectors which are either non-interchangeable screw-threaded (NIST) or non-interchangeable quick-connectors of terminal units

3.13
line pressure regulator
pressure regulator with a maximum inlet pressure of 3 000 kPa intended to be fitted within a medical gas pipeline system

3.14
low-pressure hose assembly
assembly which consists of a hose with permanently attached gas-specific inlet and outlet connectors

3.15
manifold
device for connecting the outlet(s) of one or more sources of the same medical gas within the pipeline system

3.16
manifold pressure regulator
pressure regulator with a maximum inlet pressure of 20 000 kPa intended to be installed within sources of supply containing cylinders

3.17
maximum distribution pressure
pressure downstream of any terminal unit when the pipeline distribution system is operating at zero flow

3.18
medical gas pipeline system
omplete system which comprises a source of supply, a pipeline distribution system and terminal units at the points where medical gases or anaesthetic gas scavenging may be required

3.19
medical oxygen concentrator
system comprising compressor(s), nitrogen adsorber unit(s) and reservoir by means of which oxygen-enriched, clean, dry, oil-free air is generated from atmospheric air

NOTE One example is a pressure swing adsorber.

3.20
minimum distribution pressure
lowest pressure downstream of any terminal unit when the pipeline distribution system is operating at the system design flow

3.21
nominal distribution pressure
pressure which the pipeline distribution system is intended to deliver at the terminal units

3.22
nominal supply system pressure
pressure which the supply system is intended to deliver at the inlet to the line pressure regulators

3.23
non-cryogenic liquid system
ource of supply containing liquified gas stored under non-cryogenic conditions

3.24
non-return valve
valve which permits flow in one direction only

3.25
operating alarm
visual or visual and auditory alarm to indicate the necessity for technical staff to adjust the supply or to correct a malfunction

3.26
pipeline distribution system
part of a pipeline system linking the source of supply to the terminal units, including any necessary branch isolation valves and additional line pressure regulators as required

3.27
pressure-relief valve
valve to limit pressure

3.28
primary supply
portion of the source of supply which supplies the pipeline distribution system

3.29
proportioning system
central supply system in which gases can be mixed in specified ratios

3.30
reserve supply
portion of the source of supply which supplies the pipeline distribution system in the event of failure of the primary and secondary supplies or for emergency and maintenance purposes

3.31
secondary supply
portion of the source of supply which automatically supplies the pipeline distribution system when the primary supply becomes exhausted or fails and then becomes the primary supply

3.32
shut-off valve; isolating valve
manual or automatic valve which prevents flow in both directions when closed

3.33
single fault condition
condition in which a single means for protection against a safety hazard in equipment is defective or a single external abnormal condition is present

3.34
single stage pipeline distribution system
pipeline distribution system in which gas is distributed from the source of supply at the nominal distribution pressure

3.35
source of supply
supply system with associated control equipment which supplies the pipeline

3.36
system design flow
flow calculated from the maximum flow requirements of the health care facility corrected by the operational diversity factor

3.37
terminal unit
outlet assembly (inlet for vacuum and for AGSS) in a medical gas pipeline system at which the operator makes connections and disconnections

3.38
vacuum system
source of supply with vacuum pumps designed to provide a vacuum

4 General requirements

4.1 Safety

Pipeline systems shall, when installed, commissioned, operated in normal use, and maintained according to the instructions of the manufacturer, cause no safety hazard which could be foreseen using risk analysis procedures in accordance with EN 1441 and which is connected with their intended application, in normal condition and in single fault condition.

4.2R Alternative construction

Pipeline installation and components or parts thereof, using materials or having forms of construction different from those detailed in this standard, shall be accepted if it can be demonstrated that an equivalent degree of safety is obtained.

Such evidence shall be provided by the manufacturer.

4.3 Materials

4.3.1R The manufacturer shall disclose, upon request, evidence of the corrosion resistance and of the compatibility of the materials used for pipelines, and for all components of the system, with oxygen under the operating conditions specified by the manufacturer.

NOTE 1 Corrosion resistance includes resistance against the influence of moisture and the surrounding materials in contact with the components.

NOTE 2 Compatibility with oxygen involves both combustibility and ease of ignition. Materials which burn in air will burn violently in pure oxygen. Many materials which do not burn in air will do so in pure oxygen, particularly under pressure. Similarly, the ignition energy in oxygen is lower than that in air. Many such materials can be ignited by adiabatic compression produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

NOTE 3 A standard, "*Compatibility of medical equipment with oxygen*" (prEN 13159) is under preparation by CEN/TC 215.

4.3.2R All components of the systems which can be exposed to cylinder pressure in normal or in single fault condition shall withstand a pressure of 1,5 times the cylinder pressure for 15 min.

Evidence shall be provided by the manufacturer.

4.3.3R All components of the systems which can be exposed to cylinder pressure in normal or in single fault condition shall not ignite when submitted to oxygen pressure shocks. The test for ignition is given in **6.2.8** of EN 738-2:1998.

Evidence shall be provided by the manufacturer.

4.3.4R All non-metallic components of the systems, including lubricants and thread sealants, which in normal condition are exposed to the nominal supply system pressure shall have an autoignition temperature not lower than 200 °C; all non-metallic components of the systems, including lubricants and thread sealants, which in normal condition are exposed to the nominal distribution pressure shall have an autoignition temperature not lower than 160 °C.

Compliance shall be demonstrated by testing in accordance with **6.4** of EN 738-2:1998 or by providing evidence from published data.

4.3.5R If lubricants are used, they shall be compatible with oxygen, the other medical gases and their mixtures at the operating conditions specified by the manufacturer.

Evidence shall be provided by the manufacturer.

4.3.6R All components of the system which are liable to come in contact with the medical gas shall be supplied clean and free from oil, grease and particulate matter.

Evidence shall be provided by the manufacturer.

NOTE 1 Any method of cleaning and degreasing can be used which effectively removes all surface dirt and hydrocarbons, and which leaves no residue itself. Chemical cleaning methods will normally require a subsequent washing and drying process to remove residues.

NOTE 2 Examples of cleaning procedures will be described in a standard, "*Compatibility of medical equipment with oxygen*" (prEN 13159) which is under preparation by CEN/TC 215.

4.3.7R Pipeline components which come into contact with the gas shall be protected against the ingress of contaminants prior to and during installation.

4.3.8R Metallic materials shall be used for compressed medical gas pipelines. If copper pipes of ≤54 mm diameter are used for pipelines, they shall comply with prEN 13348:1998. Pipes of materials other than copper used for compressed medical gases shall comply with the cleanliness requirements of prEN 13348:1998.

Evidence shall be provided by the manufacturer.

NOTE 1 Copper pipes of ≥54 mm diameter can be used for vacuum. Such pipes need not comply with prEN 13348:1998.

NOTE 2 Copper is the material normally used for pipelines.

NOTE 3 Non-metallic materials can be used for vacuum pipelines.

5 Source of Supply

5.1 General requirements

5.1.1 The sizing of the storage capacity of any source of supply and its reserve shall be based on the estimated usage and the frequency of delivery by the gas supplier.

NOTE The capacity of the primary, secondary and reserve supplies of all sources of supply should be defined by hospital management in consultation with the manufacturer and the gas supplier.

The number of cylinders held in store should also be defined. Appropriate storage facilities for cylinders should be provided in accordance with the relevant requirements.

5.1.2 All sources of supply shall cause no interruption of gas supply in normal condition and in single fault condition.

NOTE Loss of mains electrical power is a single fault condition.

5.1.3 The source of supply shall consist of one or more of the following:

a) gas in cylinders (Figures A.1 and A.2);

b) non-cryogenic liquid in cylinders (Figures A.1 and A.2);

c) cryogenic liquid in mobile vessels (Figures A.3 and A.4);

d) cryogenic liquid in stationary vessels (Figures A.5 to A.8);

e) an air compressor system (Figures A.9 to A.16);

f) a proportioning system (Figures A.17 and A.18);

g) a vacuum system (Figure A.19).

5.1.4 All pressure regulators shall be capable of controlling pipeline pressure at levels which meet the requirements specified in Table 1.

Table 1 — Change from nominal distribution pressure %

	Maximum distribution pressure %	**Minimum distribution pressure** %	**Test flow** l/min
Compressed medical gases	+10	−10	40
Air and nitrogen for driving surgical tools	+15	−15	350
Vacuum	0	not applicable	25

NOTE 1 The following factors will contribute to the pressure change:
— performance of line pressure regulators;
— pressure drop in the pipeline downstream of the line pressure regulator;
— pressure drop across the terminal unit.

NOTE 2 Examples of diversity factors are given in HTM 2022 and NF S 90-155.

5.1.5 Control systems shall be designed so that regulators and automatic change-over devices can be maintained without interrupting the gas supply to the pipeline distribution system, e.g. with duplex components or by-pass.

5.1.6R For pipeline systems for oxygen, nitrous oxide, air for breathing, carbon dioxide and oxygen/nitrous oxide mixture [50/50 % (*V*/*V*)] the pressure supplied to the terminal units shall not exceed 1 000 kPa in single fault condition of any pressure regulator installed within the system. Means such as pressure relief valves shall be provided to prevent this from occurring; bursting discs shall not be used.

Evidence shall be provided by the manufacturer.

> NOTE Attention is drawn to a series of European Standards, "prEN 1268, *Safety devices for the protection against excessive pressure*", which is in preparation by CEN/TC 69.

5.1.7R For pipeline systems for air and nitrogen for driving surgical tools the pressure supplied to the terminal units shall not exceed 2 000 kPa in single fault condition of any pressure regulator installed within the system. Means such as pressure relief valves shall be provided to prevent this from occurring; bursting discs shall not be used.

Evidence shall be provided by the manufacturer.

> NOTE Attention is drawn to a series of European Standards, "prEN 1268, *Safety devices for the protection against excessive pressure*", which is in preparation by CEN/TC 69.

5.1.8 For all gases, except for air, the means of pressure relief shall be vented to the outside of the building.

5.1.9 Means of pressure relief shall not be isolated from the pipeline or the pressure regulator to which it is connected.

If a valve or a flow-limiting device is incorporated for maintenance it shall be opened by the insertion of the means of pressure relief.

5.1.10 The pipeline systems shall be provided with a main shut-off valve adjacent to the source of supply.

5.1.11 Except for pipelines for air or nitrogen for driving surgical tools, an emergency and maintenance inlet point shall be provided downstream of the main shut-off valve.

5.1.12R The emergency and maintenance inlet point shall be gas-specific [e.g. by using one or more non-interchangeable screw threaded (NIST) bodies] and shall have a means of pressure-relief and a shut-off valve. The inlet shall be physically protected to prevent tampering and unauthorized access.

If NIST bodies are not used, evidence of gas-specificity shall be provided by the manufacturer.

NOTE 1 See also annex G.

NOTE 2 The emergency and maintenance inlet point can be located outside of the area of the source of supply and should preferably allow access by vehicles.

NOTE 3 The dimensions of the inlet point should take into account the system design flow.

5.1.13 The reserve supply shall be permanently connected and shall be operated either manually or automatically in the event of both the primary and the secondary supplies being unable to supply the pipeline or for maintenance purposes. In both cases, this connection shall be downstream of the main shut-off valve.

5.2 Supply system with cylinders

NOTE Typical supply systems with gas or non-cryogenic liquid cylinders are shown in Figures A.1 and A.2.

5.2.1 A cylinder manifold system shall have two banks (or groups) of cylinders or cylinder bundles which alternately supply the pipeline, each bank having its cylinders connected to a common header with a separate manifold pressure regulator complying with EN 738-2:1998. When the content of the primary bank becomes exhausted, the secondary bank shall come into operation automatically to supply the pipeline system.

NOTE 1 When an exhausted bank of cylinders is replaced, it is permissible for the automatic change-over to be reset either manually or automatically.

NOTE 2 Vent valves can be fitted on cylinder manifolds. If fitted, the valve outlets should be vented outside of the building.

5.2.2 Except for reserve supplies and cylinder banks with less than two cylinders, a non-return valve shall be installed at the manifold end of each flexible connector between the cylinder and the manifold. Reserve supplies with more than one cylinder shall be fitted with either a manually operated valve or a non-return valve.

5.2.3 A cylinder supply system shall comprise:

a) a primary supply which supplies the pipeline;

b) a secondary supply which shall operate automatically to supply the pipeline as the primary becomes exhausted;

c) a reserve supply.

5.2.4 A filter having a pore size no greater than 100 µm shall be provided between the cylinder(s) and the first pressure regulator or within the manifold pressure regulator, if fitted.

5.2.5 The flexible connections between the cylinders and the manifold, intended to be disconnected during cylinder changing operations, shall be gas-specific at the cylinder valve connection in accordance with EN 850, ISO 5145 or with the relevant national standards (see ISO/TR 7470 for information).

5.2.6 The flexible connections between the cylinders and the manifold, intended to be disconnected during cylinder changing operations, shall be marked with the following:

— the name and/or the trademark of the manufacturer and/or supplier;

— the symbol and/or the name of the gas or the gas mixture;

— means to ensure traceability such as batch or serial number or year of manufacture.

5.2.7R Means shall be provided to prevent incorrect replacement of the flexible connections between the cylinders and the manifold, e.g. by the use of gas-specific connections at the manifold.

Evidence shall be provided by the manufacturer.

5.2.8R Polymer-lined flexible hoses shall not be used as flexible connections between the cylinders and the manifolds.

NOTE A standard, "*High pressure flexible connections for use with medical gases*", is under preparation by CEN/TC 215/WG3.

5.3 Supply systems with mobile or stationary cryogenic vessels

NOTE 1 Typical supply systems with mobile cryogenic vessels are shown in Figures A.3 and A.4. Typical supply systems with stationary cryogenic vessels are shown in Figures A.5 to A.8.

NOTE 2 Standards for cryogenic vessels are in preparation by CEN/TC 268, "*Cryogenic vessels*".

5.3.1 The supply system with mobile or stationary cryogenic vessels shall comprise three sources of supply and shall be one of the following:

a) one vessel and a reserve supply with two banks of cylinders;

b) two vessels and a reserve supply with one bank of cylinders.

5.3.2 All bulk liquid vessel connectors shall be gas-specific and non-interchangeable between services. Adaptors shall not be used.

NOTE The source of supply should be fitted with an outlet where a sample can be taken for analysis.

5.3.3 A supply system with mobile or stationary cryogenic vessels shall be provided with a means to relieve excess pressure arising from the evaporation of entrapped cryogenic liquid.

NOTE A means of pressure relief can consist of one or more pressure relief valves or bursting discs.

5.4 Air systems

5.4.1 *General Requirements*

5.4.1.1 A supply system for air for breathing and for driving surgical tools shall be one of the following:

a) an air compressor system as specified in **5.4.2**;

b) a proportioning system as specified in **5.5**;

c) a cylinder supply system as specified in **5.2**.

5.4.1.2 If the air for breathing or the air for driving surgical tools is used for purposes such as:

a) the operation of ceiling columns;

b) anaesthetic gas scavenging systems;

c) breathing air for medical personnel;

d) testing of medical equipment;

e) hyperbaric chambers,

means shall be provided to prevent back-flow into the pipeline of air for breathing and into the pipeline of air for driving surgical tools. The flow requirements of these applications shall be taken into account.

5.4.1.3 The air for breathing and the air for driving surgical tools shall not be used for applications such as:

a) sterilizing systems;

b) pneumatic control of air conditioning;

c) general workshop use;

d) motor repair workshop;

e) spray painting;

f) tyre inflation;

g) reservoirs for pressurization of hydraulic fluids;

h) those applications which can impose unforeseen demands which could prejudice the availability and/or quality of air for normal patient care purposes.

5.4.1.4 Not used.

5.4.1.5 Not used.

5.4.2 ***Air compressor system***

NOTE Typical air compressor systems are shown in Figures A.9 to A.16.

5.4.2.1 The supply system for air for breathing shall contain at least three air sources. An air source is a compressor unit or a single cylinder bank or a proportioning unit.

During normal maintenance on any one air source, a second air source shall provide the system design flow. In the case of a single fault condition on the second air source whilst maintenance is in progress on the first air source, a third air source shall be capable of supplying the pipeline system with the design flow.

In an air compressor system with more than one compressor, there shall be at least two conditioning systems.

NOTE 1 An air compressor system for air for breathing typically comprises one of the following:

a) one compressor unit with one receiver, a single conditioning system and a reserve supply with two banks of cylinders;

b) two compressor units with one receiver, a duplex conditioning system and a reserve supply with two banks of cylinders;

c) two compressor units with two receivers, a duplex conditioning system and a reserve supply with one bank of cylinders;

d) two compressor units with two receivers, a duplex conditioning system and a proportioning unit as a reserve supply;

e) three compressor units with two receivers and a duplex conditioning system.

NOTE A compressor unit normally comprises the following:

a) an inlet filter;

b) a silencer;

c) a compressor;

d) after-cooler with shut-off valve and automatic drain;

e) a separator with shut-off valve and automatic drain.

NOTE A conditioning system normally comprises the following:

a) a dryer with shut-off valve and automatic drain;

b) a pre-filter;

c) an activated charcoal filter;

d) a particle filter;

e) a dew point alarm switch.

5.4.2.2 If the air for driving surgical tools is not derived from an air compressor system for air for breathing and an independent air compressor system for driving surgical tools is provided, it shall contain two air sources.

NOTE An air compressor system for driving surgical tools typically comprises one the following:

a) one compressor unit with one receiver, a single conditioning system and a reserve supply with a single bank of cylinders;

b) two compressor units with two receivers and a duplex conditioning system.

5.4.2.3 Receivers shall comply with EN 286-1. Each receiver shall be fitted with a shut-off valve, an automatic drain, a pressure gauge and a pressure-relief valve. Each group of receivers shall be arranged so as to allow each receiver in that group to be maintained separately.

NOTE Means should be provided to prevent corrosion of the receivers.

5.4.2.4 The system shall be fitted with pressure control device(s) to control the operation of the compressor(s).

5.4.2.5 If a duplex conditioning system is fitted, it shall be arranged to allow the components to be maintained separately.

5.4.2.6 When more than one compressor unit is fitted, each compressor shall have a control circuit arranged so that shutting off, or failure, of one compressor will not affect the operation of other compressor(s). The automatic controls for multiple compressors shall be arranged so that all the units will supply the system in turn or simultaneously.

5.4.2.7 All air systems shall comply with **5.1.2**.

NOTE It can be necessary to connect some air sources to the emergency electrical power supply.

5.4.2.8 The intake for the air compressors shall be located in a position where there is minimal contamination from internal combustion engine exhaust, vacuum systems, anaesthetic gas scavenging systems, ventilation system discharge and other contaminants. The air intake shall be provided with means to prevent the intake of insects and particulate matter.

5.4.2.9 Except when supplying a double stage distribution system, an air compressor system shall include a pressure-regulating system to maintain a constant pressure in the pipeline distribution system. In the case of air for breathing, supplied by three or more compressors without a cylinder bank as a reserve supply, the pressure regulating system shall be duplexed.

5.4.2.10 A flexible connection shall be installed between each compressor and the pipeline to prevent transmission of vibration.

5.4.2.11R Means shall be provided to prevent the release of toxic products into the breathing air supplied by air compressors.

Evidence shall be provided by the manufacturer.

5.5 Proportioning systems

NOTE 1 A typical proportioning system, for example for blending oxygen and nitrogen to produce synthetic air for breathing [a mixture of approximatively 21 % oxygen and 79 % nitrogen (*V/V*)], is shown in Figures A.17 and A.18.

NOTE 2 A proportioning system typically consists of a proportioning unit and a reserve supply with two banks of cylinders.

NOTE 3 The proportioning unit normally comprises the following:

a) a mixer provided with a pressure controlled shut-off valve, a pressure regulator and a non-return valve for each of the gases (e.g. oxygen and nitrogen);

b) a receiver fitted with a pressure-relief valve;

c) an analyser connected downstream of the receiver;

d) a pressure controlled shut-off valve connected downstream of the receiver.

5.5.1 The sources of supply of medical gases for proportioning systems shall conform to the requirements of **5.1** to **5.3** and may be the same sources as those supplying the medical gas pipelines separately. Means shall be used to prevent cross contamination between gases.

5.5.2 A source of supply of air for breathing employing a proportioning system shall include a reserve supply in the form of two banks of cylinders and which shall be permanently connected downstream of the main shut-off valve.

5.5.3 A proportioning system shall operate automatically. The mixture shall be analysed continously and a recording capability shall be provided, e.g. via a data port. This analysing system shall be completely independent of any analyser, if provided, which is used to control the proportioning system. If the mixture goes out of specification, an alarm shall be activated, the proportioning system shall be automatically disconnected and changed-over to the reserve supply. The system shall be arranged so that manual intervention is necessary to correct the composition of the mixture before reconnecting the proportioning system to the pipeline system.

5.5.4 A proportioning system shall be capable of supplying a mixture of the required composition over the entire range of specified flows.

5.5.5 A proportioning system shall include means for verifying the calibration of the analysing systems by reference to mixture(s) of known composition.

5.6 Vacuum systems

NOTE Typical vacuum systems are shown in Figure A.19.

5.6.1 A source of supply shall comprise three or more vacuum pumps, one or more reservoirs, two or more bacterial filters and one or more drainage traps.

5.6.2 The flow of the source of supply shall be such that the system design flow can be supplied with two units out of service.

5.6.3 Controls for the pump(s) shall be provided to activate the additional pump(s) automatically should the operating pump of the system be incapable of maintaining an adequate vacuum.

5.6.4 Each pump of the source of supply shall have a control circuit arranged so that shutting-off, or failure, of one pump will not affect the operation of other pump(s).

5.6.5 All vacuum systems shall comply with **5.1.2.**

NOTE It will be necessary to connect some vacuum sources to the emergency electrical power supply.

5.6.6 Reservoirs shall comply with appropriate pressure vessel standards.

NOTE Means should be provided to prevent corrosion of the reservoirs.

5.6.7 A drain valve shall be fitted to each reservoir.

5.6.8 The exhaust from the vacuum pumps shall be piped to the outside and shall be provided with a means to prevent the intake of insects and particulate matter. It shall be in a position where risk of contamination of occupied buildings is minimized.

NOTE The exhaust can be provided with a silencer and a drain valve.

5.6.9 A flexible connection shall be installed between the vacuum pump and the pipeline to prevent the transmission of vibrations.

5.7 Location of cylinder manifolds

The location of cylinder manifolds shall be defined in collaboration with the local Authorities and in accordance with the appropriate standards. Informative guidelines are given in annex B.

5.8 Location of stationary cryogenic vessels

The location of stationary cryogenic vessels shall be defined in collaboration with the local authorities and in accordance with the appropriate standards. Informative guidelines are given in annex B.

5.9 General requirements for supply plants

5.9.1 The ambient temperature in enclosures or rooms for supply systems for any gas supplied in cylinders shall not exceed 50 °C.

Means shall be provided to prevent loss of pressure or gas separation in cylinders of nitrous oxide, oxygen/nitrous oxide mixtures and carbon dioxide.

5.9.2 Unless otherwise stated by the manufacturers of air compressors, vacuum pumps and proportioning systems, the temperature in the plant rooms for such equipment shall not exceed 40 °C and shall not be less than 10 °C.

5.9.3 Vacuum and air compressor plants, shall be located separately from other medical gas sources of supply. The location shall be provided with drainage facilities. Guidelines for other requirements are given in annex F.

NOTE Vacuum and air compressor plants should be installed in a well lit, ventilated and clean location.

5.9.4 All sources of supply shall be readily accessible for maintenance.

5.10 Double stage pipeline distribution system

For emergency and maintenance purposes shut-off valves shall be fitted upstream and downstream close to the line pressure regulators together with one of the following:

a) a gas-specific connector (either a NIST body or the socket of a terminal unit) downstream of the downstream shut-off valve;

b) a second line pressure regulator with shut-off valves upstream and downstream;

c) gas-specific connectors (either a NIST body or the socket of a terminal unit) upstream of the upstream shut-off valve and downstream of the downstream shut-off valve.

NOTE Typical double stage pipeline distribution systems are shown in Figures A.2, A.4, A.6, A.8, A.13, A.14, A.15, A.16, and A.18. Alternative arrangements for line pressure regulators in accordance with **5.10** are shown in Figure A.20.

6 Monitoring and alarm systems

NOTE The monitoring and alarm systems have three major functions with different purposes, namely, operating alarms, emergency operating alarms, and clinical emergency alarms. The purpose of the operating alarms is to notify the technical staff that one or more sources within a source of supply is no longer available for use and it is essential that action be taken. Emergency operating alarms indicate abnormal pressure within a pipeline and could require emergency action by the technical staff. Clinical emergency alarms indicate abnormal pressure within a pipeline and could require emergency action by the clinical staff.

6.1 Installation requirements

6.1.1 If not specified in this European Standard, the location of indicator panels shall be determined by the hospital management using risk analysis procedures in accordance with EN 1441.

6.1.2 Monitoring and alarm systems, whether for operating or emergency purposes, shall comply with the following requirements:

a) the design shall allow continuous observation of the indicator panels;

b) the indicator panels for the emergency operating alarm signals specified in **6.5**d), e) and f) shall also be installed at the same location as the source(s) of supply;

c) the indicator panel(s) for the clinical emergency alarm signals specified in **6.4**a), b) and c) shall be installed near to the area shut-off valve;

d) pressure gauges or indicators, if provided, shall show deviation from the nominal distribution pressure range and shall be marked to indicate the gas and the area monitored;

e) each visual indicator shall be marked according to its function;

f) the sensing devices for operating alarms listed in **6.3** and for the emergency operating alarms listed in **6.5**d), e) and f) shall be located at appropriate positions within the source of supply;

g) the sensing devices for clinical emergency alarms listed in **6.4**a), b) and c) shall be located downstream of every line pressure regulator and area shut-off valve;

h) means shall be provided for testing the activation mechanism and integrity of visual and auditory alarm signals;

i) a pressure-sensing device shall not be isolated, for example by a manually operated shut-off valve, from the pipeline to which it is connected. If a valve is incorporated for maintenance purposes, it shall be opened by the insertion of the sensing device;

j) the operating tolerance on the set point of any pressure sensing device shall not exceed ±4 %.

6.1.3 Monitoring and alarm systems shall be connected to both the normal and the emergency electrical power supplies.

6.1.4 Alarm systems shall be electrically energized under normal conditions so that the alarm is initiated on electrical failure between sensor and indicator.

6.2 Monitoring and alarm signals

6.2.1 The characteristics of the monitoring and alarm signals specified in this European Standard shall be grouped in the following categories as specified in Table 2:

a) clinical emergency alarms;

b) emergency operating alarms;

c) operating alarms;

d) information signals.

6.2.2 *Auditory signals*

6.2.2.1 If a pattern of more than two tones or frequencies is used as an auditory signal, the auditory signal(s) for clinical emergency alarms shall conform to the requirements of EN 475.

6.2.2.2 All other auditory signals shall comprise one or two tones modulated equally, e.g. at a rate of 4 Hz between two tones of 440 Hz and 880 Hz. The A-weighted sound pressure level of the auditory components of these alarm signals at a minimum volume shall be at least 2 dB above a white background level of 55 dB when tested as described in ISO 3746.

6.2.2.3 If an auditory signal can be silenced by the operator, the silencing shall not prevent the auditory signal from being activated by a new or different alarm condition.

6.2.2.4 If an emergency auditory signal can be silenced by the operator, the period of silencing shall not exceed 15 min.

6.2.2.5 If means are provided to allow permanent silencing of the auditory signal, such means shall only be accessible to the technical staff.

6.2.3 *Visual signals*

6.2.3.1 The visual signals for clinical emergency alarms shall conform to the requirements of EN 475.

6.2.3.2 The indicator colour and the characteristics of all other visual signals shall be as given in Table 2.

NOTE Visual indications should be perceived correctly and discriminated between under the following conditions (see EN 475):

a) the operator having a visual acuity of 1 (corrected if necessary); and

b) the viewpoint being at a distance of 4 m and at any point within the base of a cone subtended by an angle of 30° to the axis normal to the centre of the plane of display of the visual indication; and

c) under an ambient illuminance throughout the range of 100 lx to 1 500 lx.

6.2.4 ***Emergency and operating alarm characteristics***

6.2.4.1 There shall be a visual and a simultaneous auditory signal for clinical emergency alarms and emergency operating alarms (see Table 2).

6.2.4.2 There shall be at least a visual signal for operating alarms (see Table 2).

6.2.4.3 When the condition which has caused the alarm has cleared, the auditory signal shall reset automatically.

6.2.4.4 When the condition which has caused the alarm has cleared, the visual signal shall reset automatically or manually.

6.2.5 ***Information signals***

Information signals shall be provided to indicate normal conditions and shall consist of a visual signal.

6.2.6 ***Remote alarm extensions***

If a remote alarm extension is provided, it shall be arranged so that a failure in the external circuit will not affect the correct functioning of the main alarm.

Table 2 — Alarm categories and signal characteristics

Category	Operator response	Indicator colour	Visual signal	Auditory signal
Clinical emergency alarm	Immediate response to deal with a hazardous situation	Complying with EN 475	Complying with EN 475	Complying with EN 475[1)]
Emergency operating alarm	Immediate response to deal with a hazardous situation	red	flashing	yes
Operating alarm	Prompt response to a hazardous situation	yellow	flashing	optional
Information signal	Awareness of normal status	not red/not yellow	constant	no

[1)] If a pattern of more than two tones or frequencies is used.
NOTE Visual flashing frequencies for operating alarms and emergency operating alarms should be between 0,4 Hz and 2,8 Hz with a duty cycle between 20 % and 60 %.

6.3 Provision of operating alarms

Operating alarm signals shall be provided to indicate the following:

a) change-over from primary to secondary cylinder supply, if different from **6.3**b);

b) any primary, secondary or reserve cylinder supply below minimum pressure;

c) the pressure in any cryogenic vessel has fallen below the minimum;

d) the liquid level in the operating cryogenic vessel has fallen below the minimum defined by hospital management in consultation with the gas supplier;

e) the liquid level in the reserve cryogenic vessel has fallen below the minimum defined by hospital management in consultation with the gas supplier;

f) malfunctioning of air compressors and vacuum pumps as specified by the manufacturer;

g) not used;

h) malfunctioning of the proportioning system, as specified by the manufacturer;

i) malfunctioning of the cryogenic system, as specified by the manufacturer.

6.4 Provision of clinical emergency alarms

Clinical emergency alarm signals shall be provided to indicate the following:

a) for double stage distribution systems, the pipeline pressure downstream of any line pressure regulator deviates by more than ±20 % from the nominal distribution pressure;

b) the pipeline pressure downstream of any area shut-off valve deviates by more than ±20 % from the nominal distribution pressure;

c) the absolute pipeline pressure for vacuum upstream of any area shut-off valve has risen above 60 kPa.

6.5 Provision of emergency operating alarms

Emergency operating alarm signals shall be provided to indicate the following:

a) for double stage distribution systems, the pipeline pressure downstream of any line pressure regulator deviates by more than ±20 % from the nominal distribution pressure;

b) the pipeline pressure downstream of any area shut-off valve deviates by more than ±20 % from the nominal distribution pressure;

c) the absolute pipeline pressure for vacuum upstream of any area shut-off valve has risen above 60 kPa.

d) for single stage distribution systems, the pipeline pressure downstream of the main shut-off valve deviates by more than ±20 % from the nominal supply system pressure;

e) for double stage distribution systems, the pipeline pressure downstream of the main shut-off valve deviates by more than +20 % and –30 % from the nominal supply system pressure;

f) the absolute pipeline pressure for vacuum upstream of the main shut-off valve has risen above 60 kPa.

7 Pipelines

7.1 Except for vacuum systems, all sections of medical gas pipeline systems shall withstand a pressure of 1,2 times the maximum pressure which can be applied to that section of the pipeline in single fault condition.

7.2 The nominal distribution pressure shall be within the ranges given in Table 3.

Table 3 — Ranges of nominal distribution pressure

Gas	Nominal distribution pressure kPa
Compressed medical gases	$400^{+100\ 1)}_{0}$
Air and nitrogen for driving surgical tools	$800^{+200\ 1)}_{-100}$
Vacuum	$\leq 60^{2)}$
[1] Above atmospheric pressure. [2] Absolute pressure.	

NOTE 1 Different gases can be delivered at different nominal distribution pressure in the same hospital. In locations such as intensive care units and operating theatres means can be provided to control the nitrous oxide pressure by the oxygen pressure in order to keep the nitrous oxide pressure below the oxygen pressure.

NOTE 2 Flexible connections in pipeline distribution systems are normally used as a part of the pipeline, for example for isolation of vibration, building movement and relative movement of the pipelines.

NOTE 3 Low-pressure hose assemblies in pipeline distribution systems are normally used:

e) for emergency supply of gas to a pipeline;

f) as part of permanently fixed equipment such as booms, pendants and pendant tracks.

7.3 The maximum distribution pressure and the minimum distribution pressure shall be within the limits given in Table 1.

7.4 Line pressure regulators shall comply with EN 738-2:1998.

7.5 Low-pressure hose assemblies, if provided, shall comply with EN 739.

7.6 If the flexible connections are part of the pipeline, for example when used for isolation of vibration, building movement and relative movement of the pipelines, and are not normally replaced during their life, the assembly need not be gas-specific.

These flexible connections shall be tested as part of the pipeline in accordance with clause **12**.

8 Shut-off valves

8.1 For all shut-off valves in a medical gas pipeline system, except those in the source of supply, it shall be apparent by observation whether the valve is fully open or fully closed.

NOTE 1 Shut-off valves are classified as follows:

a) service shut-off valves;

b) area shut-off valves.

NOTE 2 Service shut-off valves are used as:

a) main shut-off valves;

b) riser shut-off valves;

c) equipment shut-off valves.

8.2 All shut-off valves shall be identified:

a) to indicate the gas service name or symbol;

b) to indicate, in a manner appropriate to their classification as given in note 1 to **8.1**, the area or section of pipeline being served or their purpose.

This identification shall be secured to the valve, valve box or service pipeline and be readily visible at the valve site.

8.3 Service shut-off valves shall either be lockable in the open or closed position or shall be protected against improper operation.

NOTE Service shut-off valves should only be used by the maintenance and operating staff and should not be accessible to unauthorized persons.

8.4 Each riser shall be provided with a riser shut-off valve.

NOTE 1 Such shut-off valves can be provided for other branches.

NOTE 2 A full-bore purge valve with a preceding lockable shut-off valve can be provided at the bottom of each vertical riser.

8.5 Except for vacuum systems, an area shut-off valve shall be provided in each gas pipeline serving each operating theatre, critical care area, intensive care area and general ward area.

NOTE The extent of the areas served by each area shut-off valve should be assessed in accordance with EN 1441. The risk assessment should also take into account the hazards arising from the possible rupture of low-pressure hose assemblies fitted within any medical supply units.

8.6 All area shut-off valves shall be located in boxes with covers or doors.

NOTE Area shut-off valves should be accessible and should be used to isolate areas within health care facilities for maintenance and emergency purposes. Their operation, in the latter case, should be included as part of the emergency disaster plan.

8.7 Each box shall contain the following:

a) an area shut-off valve;

b) a means to allow physical separation of the service(s) when modifications are carried out to existing systems, downstream of the area shut-off valve(s), which shall be clearly visible when deployed. A closed valve is not considered an adequate mechanical disconnection.

8.8 All boxes shall be vented to the room to prevent accumulation of gas and shall have covers or doors, which can be secured in the closed position. The covers or doors shall have a means of quick access in case of emergency.

8.9 All boxes shall be located within normal hand height and shall be accessible at all times.

8.10 Except for pipelines for air and nitrogen for driving surgical tools an emergency and maintenance inlet point shall be provided downstream of each area shut-off valve.

8.11 The emergency and maintenance inlet point shall be gas-specific (either a NIST body or the socket of a terminal unit).

NOTE 1 The emergency and maintenance inlet point can be located within the box.

NOTE 2 The dimensions of the inlet point should take into account the flow required during emergency and maintenance activities.

9 Terminal units, gas-specific connectors and medical supply units

9.1 Terminal units shall comply with EN 737-1.

9.2 Gas-specific connectors shall be either the gas-specific connection point of a terminal unit complying with EN 737-1 or the body of a NIST connector complying with EN 739.

9.3 Medical supply units shall comply with EN 793.

10 Marking and colour coding

10.1 Marking

10.1.1 Pipelines shall be durably marked with the gas name (and/or symbol) adjacent to shut-off valves, at junctions and change of direction, before and after walls and partitions, etc., at intervals of no more than 10 m and adjacent to terminal units.

Such marking may be made, for example, of metal tags, stencilling, stamping or with adhesive markers.

10.1.2 Shut-off valves shall be durably marked with the mode of operation.

10.1.3 Marking shall:

a) be with letters not less than 6 mm high;

b) be applied with the gas name and/or symbol to be read along the longitudinal axis of the pipeline;

c) include arrows denoting direction of flow.

10.2 Colour coding

If colour coding for pipelines is used for all or part of its length, it shall comply with EN 739 and shall be durable.

NOTE An example of test for durability of markings and colour coding is given in EN 739.

11 Pipeline installation

11.1 General

11.1.1 Pipeline systems shall be used only for patient care. No connections shall be made to systems for other uses except for the compressed air system, where extensions are permitted in accordance with the requirements of **5.4.1.2**.

NOTE If a hyperbaric chamber is provided for medical treatment, it can be necessary to install a separate pipeline(s), the appropriate pressure- and flow-control equipment and means to prevent backflow.

11.1.2 Pipeline and electrical services shall be:

a) run in separated compartments; or

b) separated by more than 50 mm.

11.1.3 The pipeline shall be bonded to an earth terminal as near as possible to the point at which the pipeline enters the building. The pipelines shall not themselves be used for earthing the electrical equipment. The relevant parts of HD 384 shall be complied with.

11.1.4 Pipelines shall be protected from physical damage, for example damage which might be sustained from the movement of portable equipment such as trolleys, stretchers and trucks, in corridors and in other locations.

11.1.5 Unprotected pipelines shall not be installed in areas of special hazard, e.g. in areas where flammable materials are stored. Where installation of pipelines in such a location is unavoidable, the pipeline shall be protected by an enclosure which will prevent the liberation of medical gas within the room should leaks occur in the pipeline system installed in the area.

NOTE Attention is drawn to national building requirements and fire regulations.

11.1.6 If pipelines for medical gases are placed in the same tunnel, trench or duct alone, with other services or with pipelines for other fluids or gases, the potential hazard arising from this situation shall be assessed in accordance with EN 1441. The risk assessment shall take into account that a leak which is not detected (e.g. by an alarm or periodic inspection) shall be considered a normal condition and not a single fault condition.

11.1.7 Pipelines shall not be installed in elevator shafts.

11.1.8 A shut-off valve shall not be installed where a leak is likely to cause an accumulation of gas, for example in a sealed cavity.

11.1.9 Damage due to contact with corrosive materials shall be minimized by the use of impermeable non-metallic materials applied to the outer surface of the pipework in the area where the contact can occur.

11.1.10 Allowance shall be made for expansion and contraction of pipelines.

11.1.11 All pipelines for medical gases shall be routed in such a way that they are not exposed to a temperature less than 5 °C above the dew point of the gas at the operating pressure.

NOTE It is not necessary to run pipelines with a fall for drainage purposes.

11.2 Pipeline supports

11.2.1 Medical gas pipelines shall be supported at intervals to prevent sagging or distortion.

NOTE Recommended maximum intervals for copper pipes are given in Table 4.

11.2.2 The supports shall ensure that the pipeline cannot be displaced accidentally from its position.

11.2.3 The supports shall be of corrosion-resistant material, or shall be treated to prevent corrosion. Means shall be provided to prevent electrolytic corrosion.

11.2.4 Where pipelines cross electric cables, the pipelines shall be supported adjacent to the cables.

11.2.5 Pipelines shall not be used as support for, nor shall they be supported by, other pipelines or conduits.

Table 4 — Recommended maximum intervals between supports for copper pipes

Outside diameter mm	Maximum intervals m
up to 15	1,5
22 to 28	2,0
35 to 54	2,5
>54	3,0

11.3 Pipeline joints

11.3.1 Except for threaded joints used for components such as shut-off valves, pressure regulators or terminal units, or where plastic materials are used for vacuum systems, all pipeline joints shall be brazed or welded. The methods used for brazing or welding shall permit the joints to maintain their mechanical characteristics up to an ambient temperature of 450 °C. Filler metals for brazing shall not contain more than 0,025 % (*g*/*g*) of cadmium.

NOTE Mechanical joints, (e.g. flanged or screwed connections), can be used to connect to the pipeline, components such as shut-off valves, terminal units, pressure regulators, control, monitoring and alarm sensors.

11.3.2 During brazing or welding of pipeline joints, the interior of the pipeline shall be purged with shield gas.

11.4 Modification and connection to existing pipeline systems

11.4.1 The flow capacity of the existing pipeline system shall meet the requirements of the extended pipeline system.

11.4.2 The final connection of extensions shall be undertaken on only one system at a time, in order to minimize the risk of cross-connections. All other systems shall remain under normal operating pressure.

NOTE Careful consideration should be given to the location of this connection to minimize problems of access in installation and testing.

11.4.3 When an extension is to be made to an existing system, the new pipeline take-off shall be equipped with an area shut-off valve at the intended point of connection to isolate the existing pipeline, except when an existing area shut-off valve can be used for this purpose.

11.4.4 When an extension is to be made to an existing system which does not fulfil the requirements specified in **12.4.11**, a duplex particle filter unit shall be fitted at the inlet of the extension.

11.4.5 During construction, the valve required by **11.4.3** shall be locked in the closed position and labelled as follows:

"Construction isolation valve – Do not open"

11.4.6 All terminal units in an extension shall be temporarily labelled to indicate they are not to be used.

11.4.7 Connection shall be made to the existing system only after the appropriate tests specified in clause **12** have been successfully completed on the modification. The area shut-off valve specified in **11.4.3** shall be opened and further relevant tests completed on the modification.

11.4.8 When modification has been completed and tested in accordance with clause **12**, all labels as specified in **11.4.6** shall be removed.

12 Testing, commissioning and certification

NOTE The aim of testing and commissioning of medical gas pipeline systems is to verify that all safety aspects and performance requirements of the systems are met. An example of a procedure for testing and commissioning is given in annex C. Tests after completion of installation should be carried out by the installer and witnessed by an authorized person qualified in the testing of medical gas pipeline systems, who should certify the results of the tests to the owner or client. The authorization can be given e.g. within the manufacturer's certified quality system complying with the appropriate parts of the series EN ISO 9000 and EN 46000 or by a notified body. The results of tests showing details of the services and areas tested should be part of the permanent record of the hospital.

12.1 General requirements for tests

12.1.1 Except for those tests where the specific gas is prescribed, purging and testing as described in **12.2.2** shall be carried out with clean, oil-free dry air or nitrogen.

NOTE Air is preferably used for oxygen and air pipelines.

12.1.2 Before any testing is carried out, every terminal unit in a system under test shall be labelled to indicate that the system is under test and it shall not be used.

12.1.3R The resolution of all pressure measuring devices shall be at most 10 % of the specified value to be measured.

12.2 Tests to be carried out

12.2.1 *Tests after installation of pipeline systems with at least the base blocks of all terminal units fitted but before concealment*

The following tests and inspections shall be carried out:

a) test for mechanical strength;

b) test for leakage;

c) test for cross-connection and obstruction;

d) inspection of marking and pipeline supports;

e) visual check that all items installed at this stage comply with the design specification.

12.2.2 *Tests and procedures after complete installation and before use of the system*

The following tests and procedures shall be carried out:

a) test for leakage;

b) test for leakage and check of shut-off valves for closure, zoning and identification;

c) test for cross-connection;

d) test for obstruction;

e) check of terminal units and NIST connectors for mechanical function, gas-specificity and identification;

f) verification of system performance;

g) test of pressure-relief valves;

h) functional tests of all sources of supply;

j) tests of control, monitoring and alarm systems;

k) purging with test gas;

l) test for particulate contamination of the pipelines;

m) filling with specific gas;

n) test of purity of air produced by compressor systems;

o) test of gas identity.

12.3 Requirements for tests listed in 12.2.1

12.3.1 *Test for mechanical strength*

Determine the maximum pressure which can be applied to the pipeline in single fault condition downstream of each pressure regulator. Apply 1,2 times maximum pressure to each section of pipeline for 15 min.

Check that the pipeline has not ruptured.

12.3.2 *Test for leakage*

The pressure drop during a test period of 2 h to 24 h shall be less than 0,025 %/h. The pressure drop shall be corrected for variations due to temperature according to the ideal gas law (see annex D for information).

The test pressure shall be a minimum of 1,5 times the nominal distribution pressure for compressed medical gas pipelines and 500 kPa for vacuum pipelines.

NOTE It can be preferable to test small sections of the system individually.

12.3.3 *Test for cross-connection and obstruction*

There shall be no cross-connection or obstruction.

12.3.4 *Inspection of marking and pipeline supports*

Marking shall comply with clause **10**. The pipeline supports shall comply with **11.2**.

12.3.5 *Compliance with the design specification*

Before concealement of the pipelines, all items shall be shown to comply with the design specification (e.g. the sizing of the pipelines, location of terminal units, line pressure regulators, if fitted, and shut-off valves).

12.4 Requirements for tests listed in 12.2.2

12.4.1 *Test for leakage*

12.4.1.1 *Leakage from the compressed gas pipeline systems*

The leakage from the completed medical gas pipeline systems shall be measured with the supply system disconnected.

After a period under test of 2 h to 24 h at nominal distribution pressure, a pressure drop might be observed in the system. The pressure drop shall not exceed the value calculated from the formula:

$$pd = 2nh/V$$

where

pd is the pressure drop in kPa;
h is the number of hours on test (between 2 and 24);
n is the number of terminal units;
V is the volumetric capacity, in litres, of the pipeline system.

NOTE 1 The formula is based on a maximum permissible leakage of 0,296 ml/min per terminal unit (0,03 kPa·l/min) according to EN 737-1.

NOTE 2 It can be preferable to test small sections of the system individually, in which case the number of terminal units (*n*) and the volumetric capacity (*V*) are those of the section under test.

12.4.1.2 *Leakage into the completed vacuum systems*

With the system at nominal distribution pressure and with the source of supply isolated, the pressure increase in the pipeline shall not exceed 20 kPa after 1 h.

12.4.1.3 *Leakage through shut-off valves in compressed medical gas pipeline systems*

With the system upstream of the closed valve under test at nominal distribution pressure, the downstream line depressurized to 100 kPa and all downstream terminal units closed, the pressure increase, after 15 min, shall not exceed 5 kPa.

12.4.2 *Check of shut-off valves*

All shut-off valves shall be checked for correct operation, identification and to show that they control only those terminal units intended by the design.

12.4.3 *Test for cross-connection*

All pipelines shall be tested to ensure that there are no cross-connections between pipelines for different gases and vacuum.

12.4.4 *Test for obstruction*

The pressure drop measured at each terminal unit shall not exceed the values specified in Table 5 when the test flow specified in Table 5 is taken from each terminal unit in turn. Each pipeline shall be at its nominal distribution pressure and connected to the test gas supply.

Table 5 — Maximum allowable pressure drop

Gas	Pressure drop %	Test flow l/min
Compressed medical gases	10	40
Air and nitrogen for driving surgical tools	15	350
Vacuum	20	25

12.4.5 *Check of terminal units and NIST connectors*

12.4.5.1 *Mechanical function*

It shall be demonstrated, for each terminal unit, that the appropriate gas-specific probe can be inserted, captured and released. If an anti-swivel device is provided, check that this retains the probe in the correct orientation.

NOTE 1 This test requires that the terminal unit is complete with its fascia plate.

It shall be demonstrated, for each NIST connector, that the appropriate nipple can be inserted into the body and secured by the nut.

NOTE 2 This test can be carried out at the same time as the tests described in **12.4.5.2**, **12.4.5.3** and **12.4.14**.

12.4.5.2 *Gas-specificity*

It shall be demonstrated for each terminal unit that gas is released only when the correct probe is inserted and captured and that no probe is captured and that no gas is released when probes for all other gases are inserted. All probes used for this test shall comply with EN 737-1.

It shall be demonstrated, for each NIST connector, that only the correct nipple is inserted into the body and secured by the nut and that no nipple for other gases is inserted and secured.

NOTE This test can be carried out at the same time as the tests described in **12.4.5.1**, **12.4.5.3** and **12.4.14**.

12.4.5.3 *Identification*

All terminal units shall be checked for correct identification and labelling.

NOTE This test can be carried out at the same time as the tests described in **12.4.5.1**, **12.4.5.2** and **12.4.14**.

12.4.6 ***Verification of system performance***

12.4.6.1 It shall be shown for each pipeline system that the nominal distribution pressure complies with the requirements of Table 3.

12.4.6.2 It shall be shown for each pipeline system that the maximum distribution pressure and the minimum distribution pressure are within the limits given in Table 1.

12.4.7R ***Test of pressure-relief valves***

The performance of pressure-relief valves, if fitted, shall be in accordance with **5.1.6** and **5.1.7**. If type-tested and certified pressure-relief valves are fitted, testing after installation is not required.

Evidence shall be provided by the manufacturer.

12.4.8 ***Functional test of all sources of supply***

Each source of supply shall be tested for operating and emergency conditions according to the manufacturer's manuals and specifications which are required by clause **13**.

12.4.9 ***Test of control, monitoring and alarm systems***

The performance of all monitoring and alarm systems shall be tested in all operating and emergency conditions.

12.4.10 *Purging with test gas*

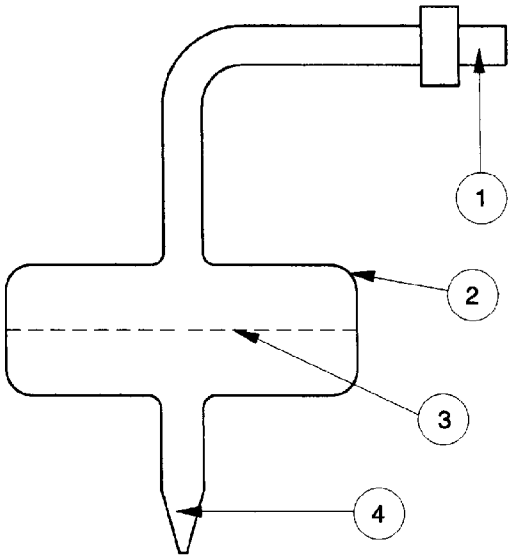
Each distribution system shall be purged with test gas to remove particulate matter. Each terminal unit shall be opened in turn.

12.4.11 *Test for particulate contamination of the pipelines*

All pipelines for compressed medical gases shall be tested for particulate contamination. The test shall be carried out using the device described in Figure 1 at a flow of 150 l/min for 15 s.

The filters shall be free from particulate matter when viewed in good light.

NOTE This test can be combined with the purging procedure specified in **12.4.10**.



1) Gas-specific probe (interchangeable)
2) Filter holder specified to withstand 1 000 kPa
3) Filter of diameter (50 ± 5) mm and pore size 10 μm
4) Calibrated jet (interchangeable) to provide a flow of 150 l/min at nominal distribution pressure

Figure 1 — Test device for determining particulate contamination in pipelines

12.4.12 *Filling with specific gas*

Each distribution system shall be filled and emptied with its specific gas for a sufficient number of times to displace the test gas. Each terminal unit shall be opened in turn to ensure that no sections of pipeline remain filled with test gas.

12.4.13 ***Test of purity of air supplied by air compressor systems***

Not used.

12.4.14 ***Test of gas identity***

A gas identity check shall be carried out on each terminal unit after purging with its specific gas.

A positive identification of each medical gas shall be carried out. A device(s) capable of positive identification of each medical gas shall be used.

NOTE This test can be carried out at the same time as the tests described in **12.4.5.1**, **12.4.5.2** and **12.4.5.3**.

12.5 Certification of the systems

12.5.1 Before a medical gas pipeline system is used, it shall be certified in writing that all the requirements of **12.3** and **12.4** have been met.

NOTE 1 Typical forms for this purpose are given in annex J.

NOTE 2 The certification can be issued in 2 parts:

— part 1: to cover testing of the requirements of **12.3** and **12.4** except for **12.4.12** and **12.4.14**;

— part 2: to cover testing of the requirements of **12.4.12** and **12.4.14**.

12.5.2 The manufacturer shall certify that all drawings and manuals, as required in clause **13**, have been supplied to the owner or client.

12.5.3 When all tests have been completed satisfactorily, all construction labels which have been fixed to terminal units shall be removed.

13 Information to be supplied by the manufacturer

13.1 Instruction manuals

The manufacturer shall provide to the owner instructions for use of the complete system. Particular attention shall be paid to:

— the supply systems;

— the monitoring and alarm systems;

— the danger of fire or explosion due to the use of oil and grease with oxygen supply and pipeline systems.

13.2 Maintenance schedules

The manufacturer shall provide to the owner instructions for recommended maintenance tasks and their frequency and a list of recommended spare parts.

13.3 "As installed" drawings

13.3.1 A separate set of "as installed" mechanical drawings which show the actual location and the diameters of the pipeline systems shall be maintained during construction, and shall be brought up to date as variations are made. These drawings shall include details which will enable buried or concealed pipelines to be located.

13.3.2 Complete "as installed" drawings as specified in **13.3.1** shall be presented to the owner of the pipeline system as a set of drawings, marked "as installed", for inclusion as part of the permanent record of the pipeline system.

NOTE If a pipeline system is altered subsequent to the transfer of the drawings to the owner, the "as installed" drawings specified in **13.3.2** should be brought up to date.

13.4 Electrical diagrams

Electrical diagrams for the complete installation shall be provided by the manufacturer to the owner.

Annex A (informative)
Schematic representation of sources of supply

A.1 General

This annex gives schematic representations of typical sources of supply for medical gas pipeline systems, as follows:

— Figures A.1, A.2: typical source of supply with gas or non-cryogenic liquid in cylinders;

— Figures A.3, A.4: typical source of supply with mobile cryogenic vessels;

— Figures A.5 to A.8: typical source of supply with stationary cryogenic vessels;

— Figures A.9 to A.16: typical source of supply with air compressor units;

— Figures A.17, A.18: typical source of supply with proportioning systems;

— Figure A.19: typical source of supply with vacuum pumps;

— Figure A.20: typical double stage distribution system with line pressure regulators within the pipeline system. Arrangements for line pressure regulators in accordance with **5.10**.

A.2 Key to Figures A.1 to A.20

1 Cylinder
2 Cylinder valve
3 Vent valve
4 Non-return valve or shut-off valve
5 Flexible connection
6 Filter
7 Pressure gauge
8 Pressure alarm switch
9 Manifold pressure regulator
10 Pressure relief valve
11 Automatic change-over
12 Change-over alarm switch
13 Shut-off valve
14 Low and high pressure emergency alarm switch
15 First stage distribution (at nominal supply system pressure)
16 Non-return valve
17 Second stage distribution (at nominal distribution pressure)
18 Terminal unit
19 Stationary cryogenic vessel with control and monitoring equipment
20 Silencer
21 Compressor
22 After-cooler
23 Separator
24 Drain
25 Pressure control switch
26 Dryer
27 Prefilter
28 Particle filter
29 Drain, optional
30 Dew point alarm switch
31 Receiver
32 Drainage trap
33 Low vacuum alarm pressure switch
34 Vacuum reservoir
35 Vacuum pump
36 Exhaust
37 Activated charcoal filter
38 Drain valve
39 Mobile cryogenic vessel
40 Reserve supply
41 Emergency/maintenance inlet
42 Gas-specific connector
43 Low pressure hose assembly
44 Main shut-off valve
45 High pressure manifold
46 Supply to pipeline system (at nominal distribution pressure)
47 Supply to pipeline system (at nominal supply system) pressure; see Figure A.20
48 Bacterial filter
49 Riser shut-off valve
50 Connection to the supply system
51 Supply to breathing air pipeline system
52 Supply to surgical tool air pipeline system
53 Pressure sensor
54 Analyser
55 Mixer with optional analyser independent of 54
56 Valve controlled by default pressure
57 From the source of supply
58 Duplexing (optional)
59 Connection to pipeline system
60 Second line pressure regulator
61 Line pressure regulator
62 Shut-off valve controlled by 53 and 54
63 Pressure regulator
64 Emergency line pressure regulator
65 Silencer, optional

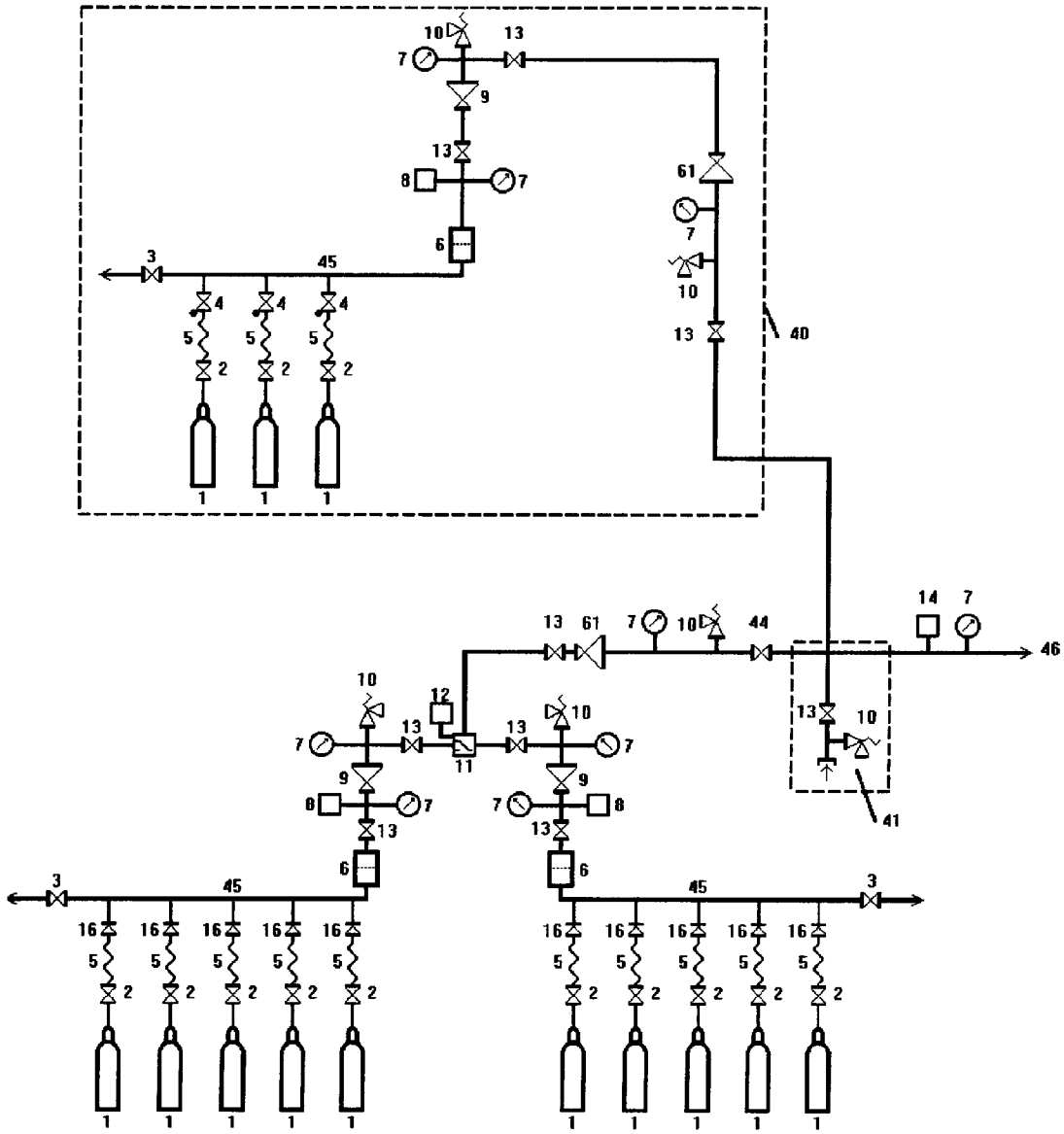


Figure A.1 — Typical source of supply with gas or non-cryogenic liquid in cylinders (single stage distribution system)

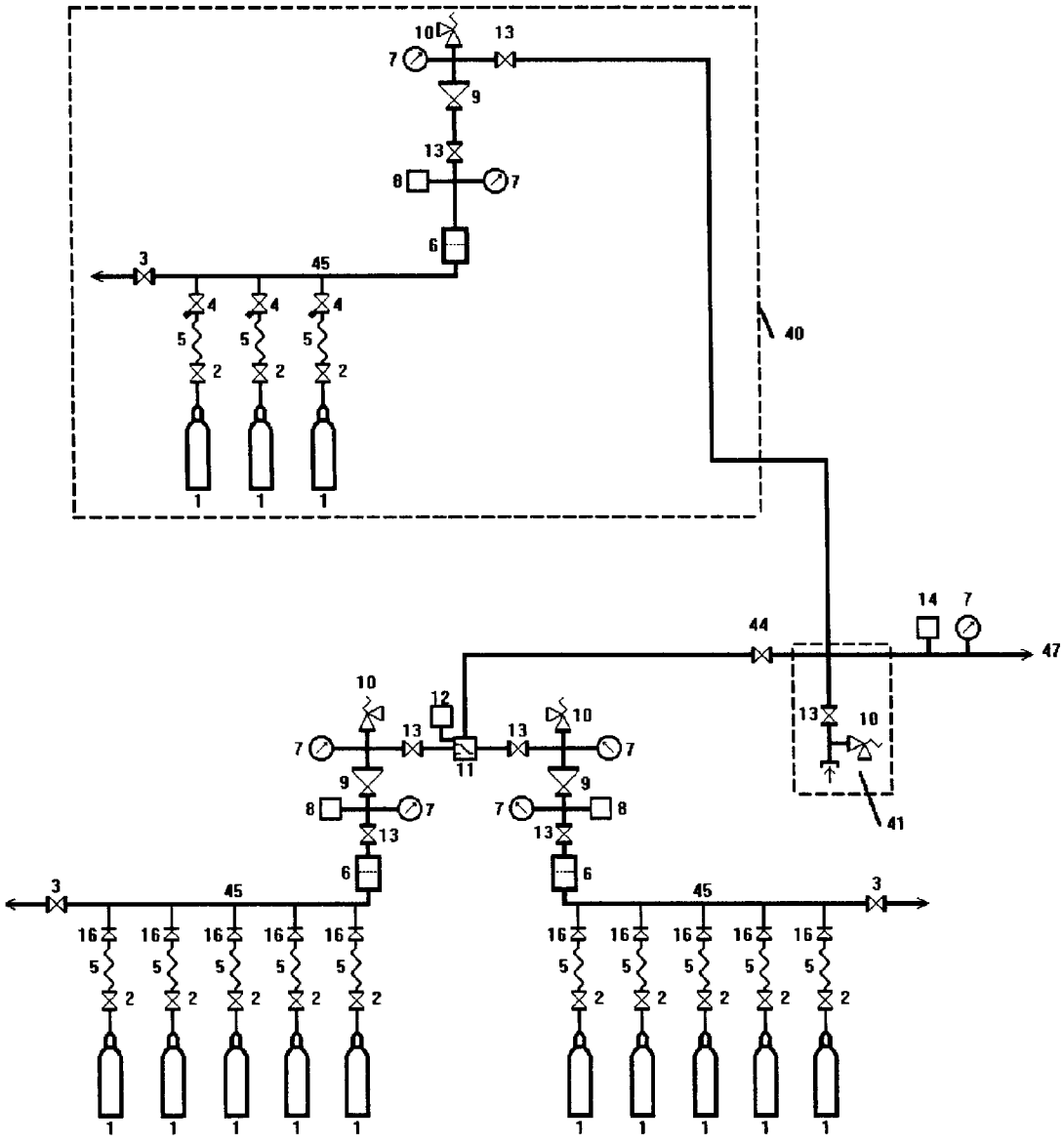


Figure A.2 — Typical source of supply with gas or non-cryogenic liquid in cylinders (double stage distribution system)

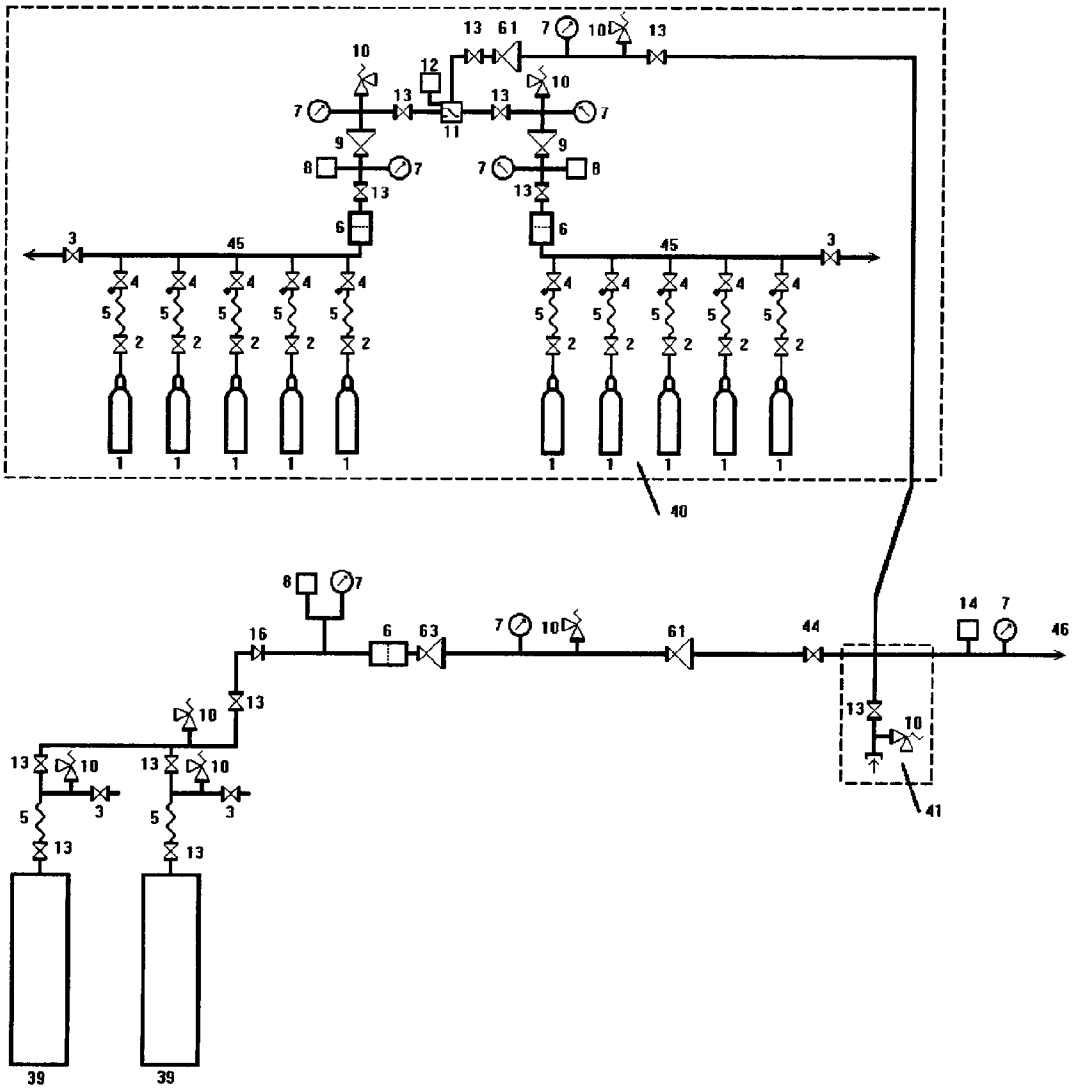


Figure A.3 — Typical source of supply with mobile cryogenic vessels (single stage distribution system)

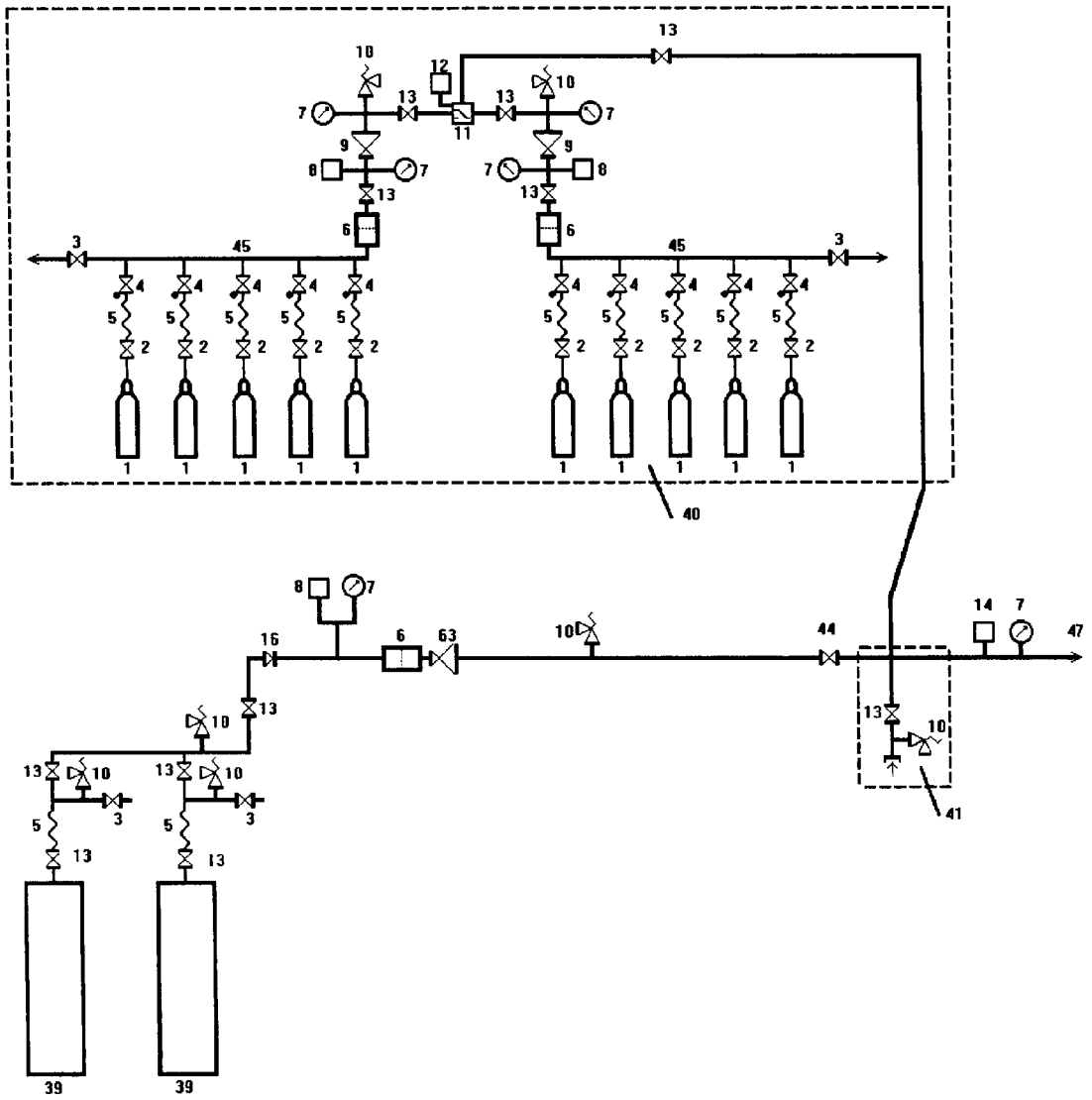


Figure A.4 — Typical source of supply with mobile cryogenic vessels (double stage distribution system)

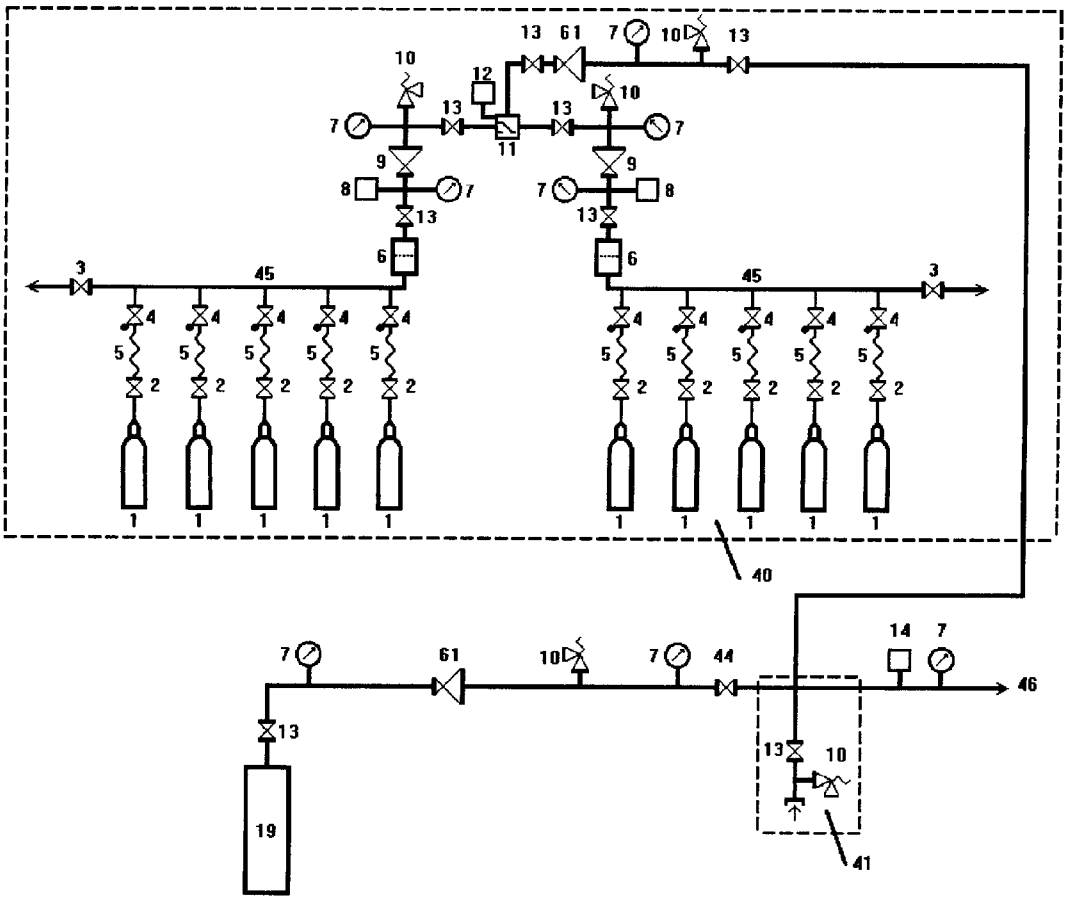


Figure A.5 — Typical source of supply with one stationary cryogenic vessel (single stage distribution system)

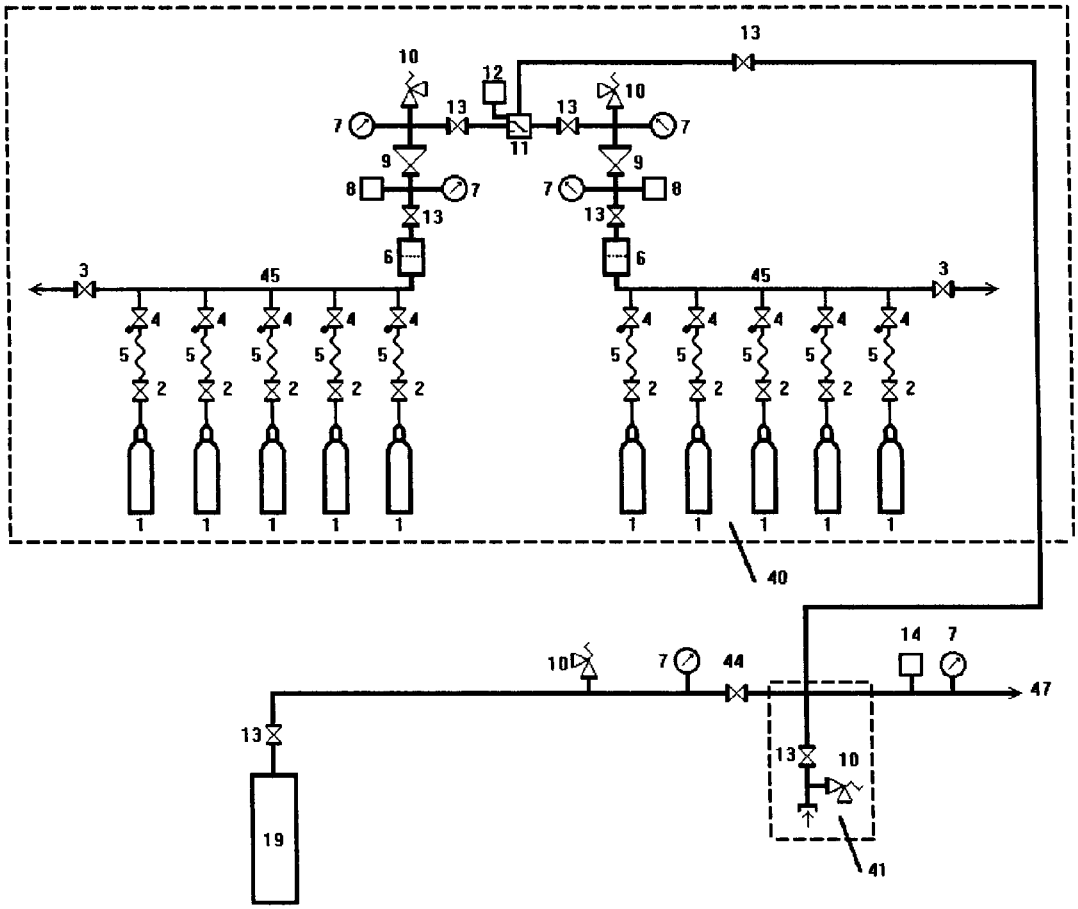


Figure A.6 — Typical source of supply with one stationary cryogenic vessel (double stage distribution system)

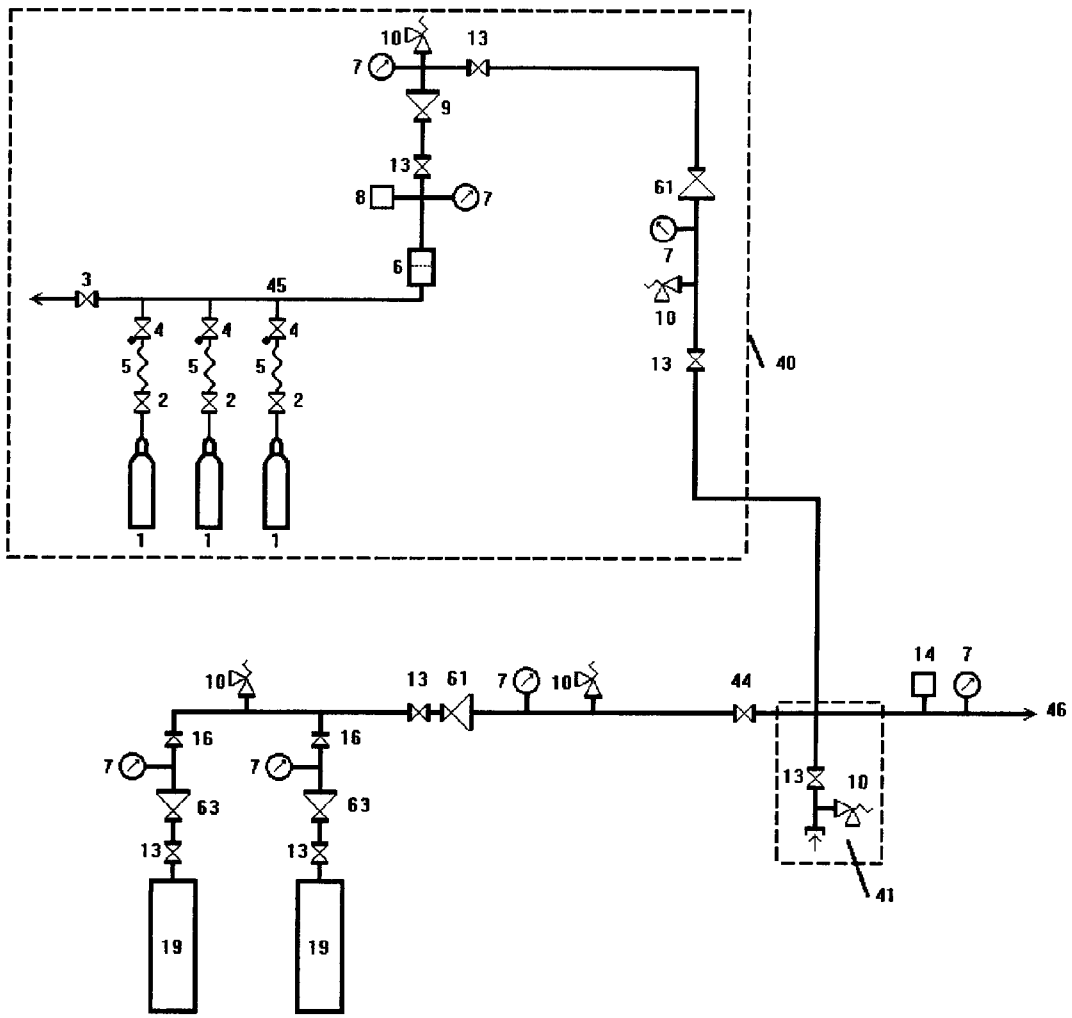


Figure A.7 — Typical source of supply with two stationary cryogenic vessels (single stage distribution system)

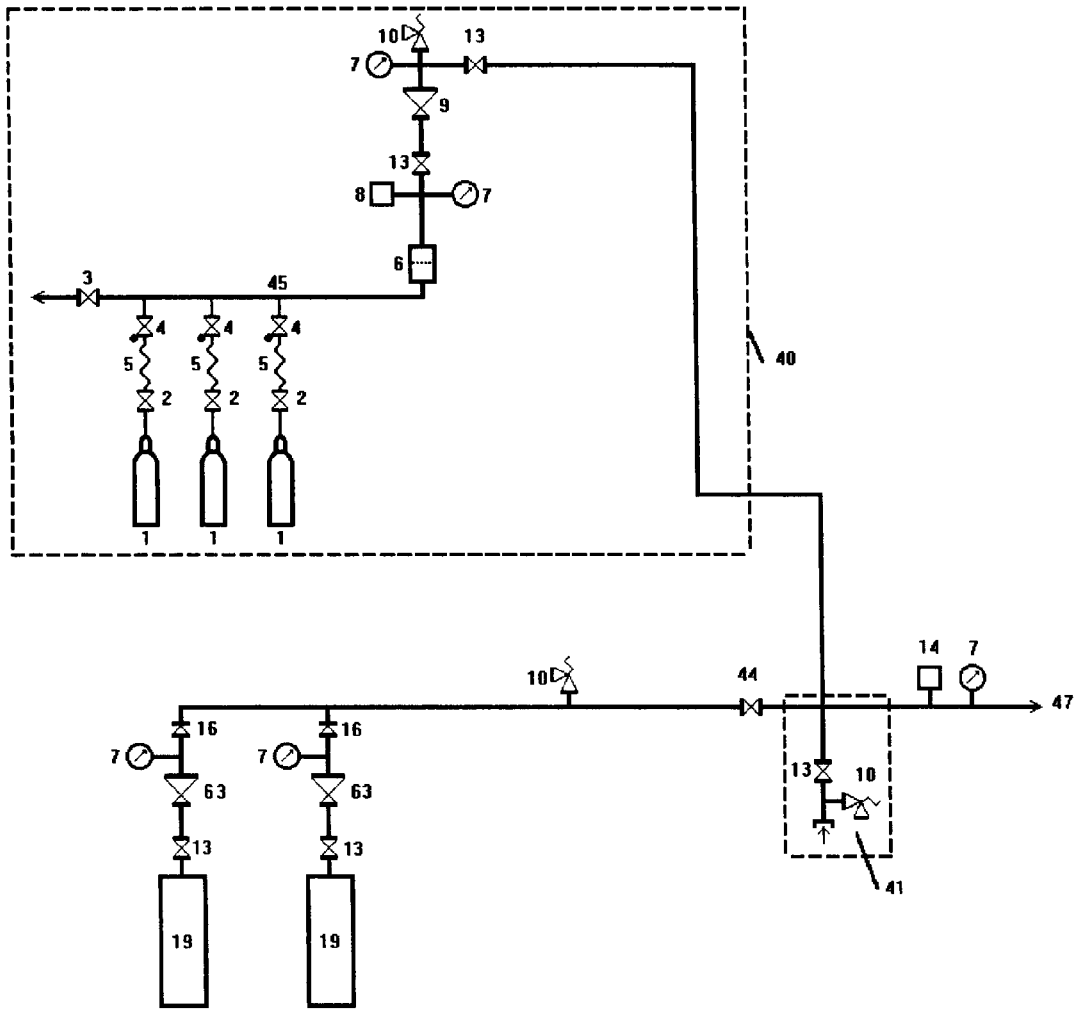


Figure A.8 — Typical source of supply with two stationary cryogenic vessels (double stage distribution system)

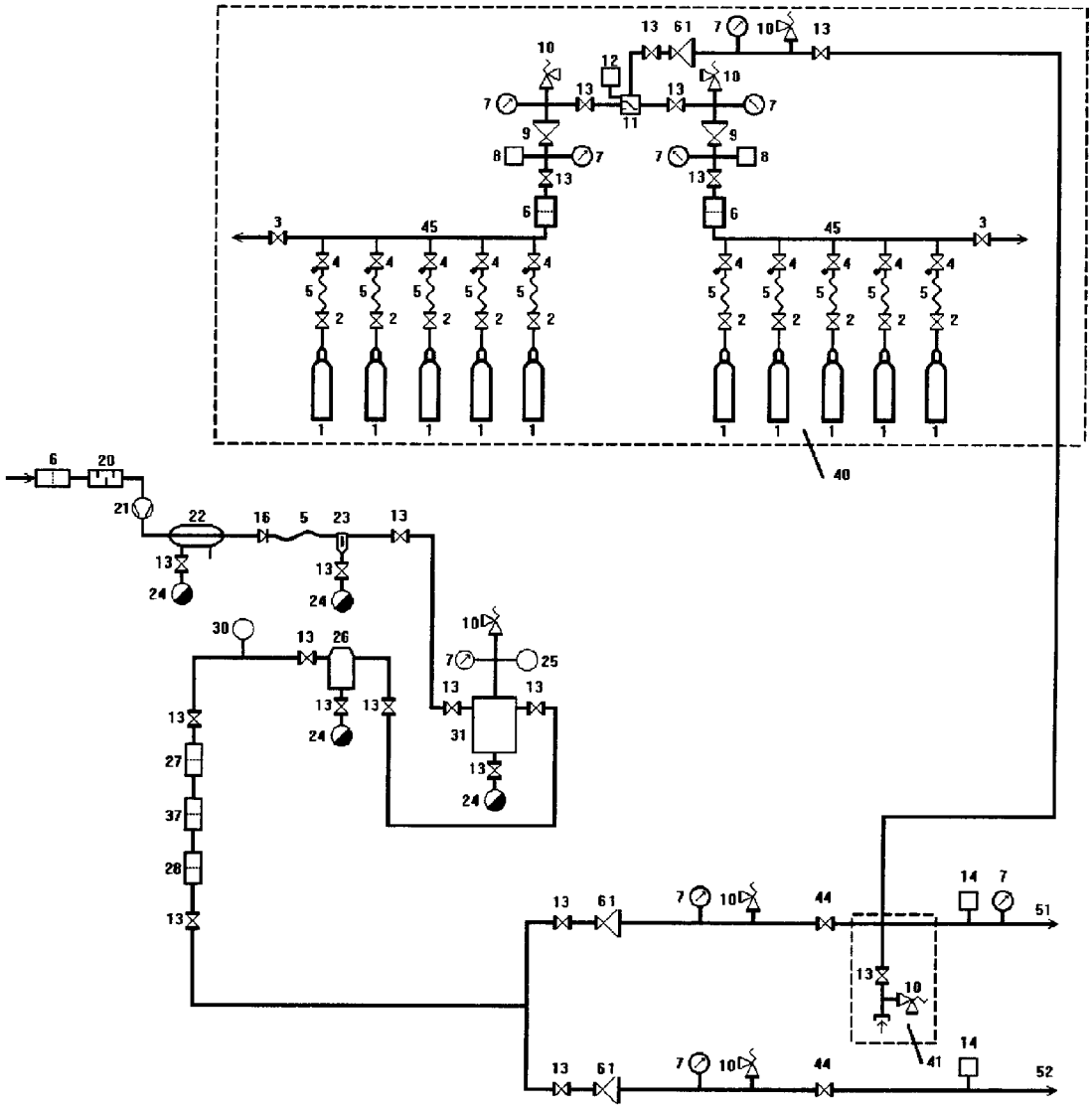


Figure A.9 — Typical source of supply with one air compressor unit and two banks of gas cylinders (single stage distribution system)

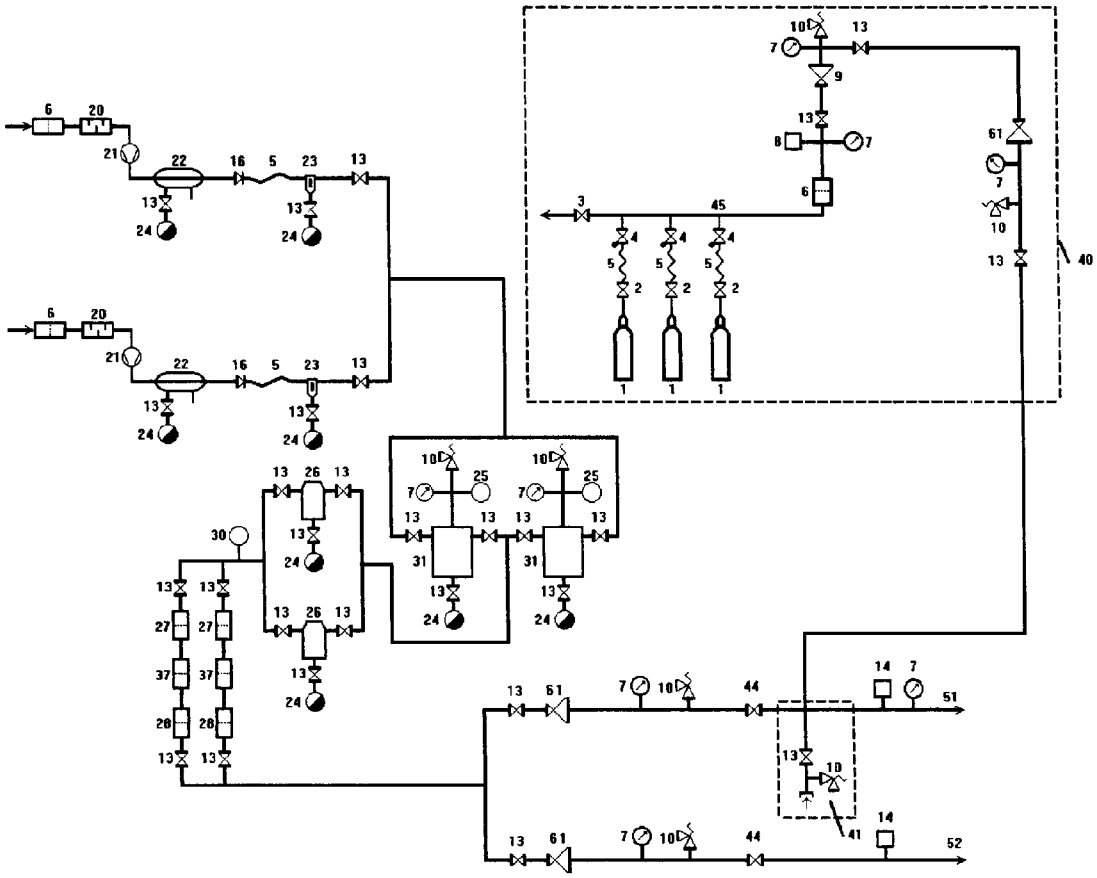


Figure A.10 — Typical source of supply with two air compressor units and one bank of gas cylinders (single stage distribution system)

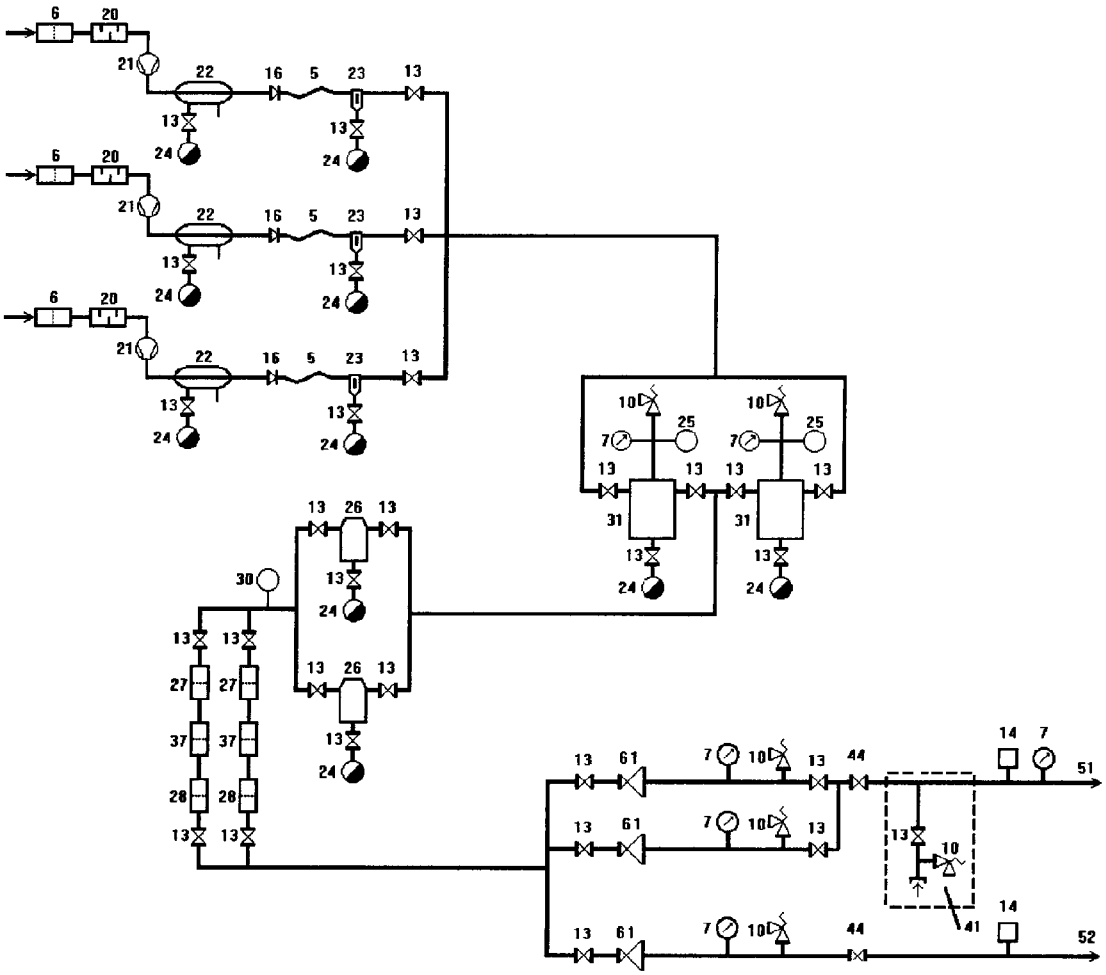


Figure A.11 — Typical source of supply with three air compressor units (single stage distribution system)

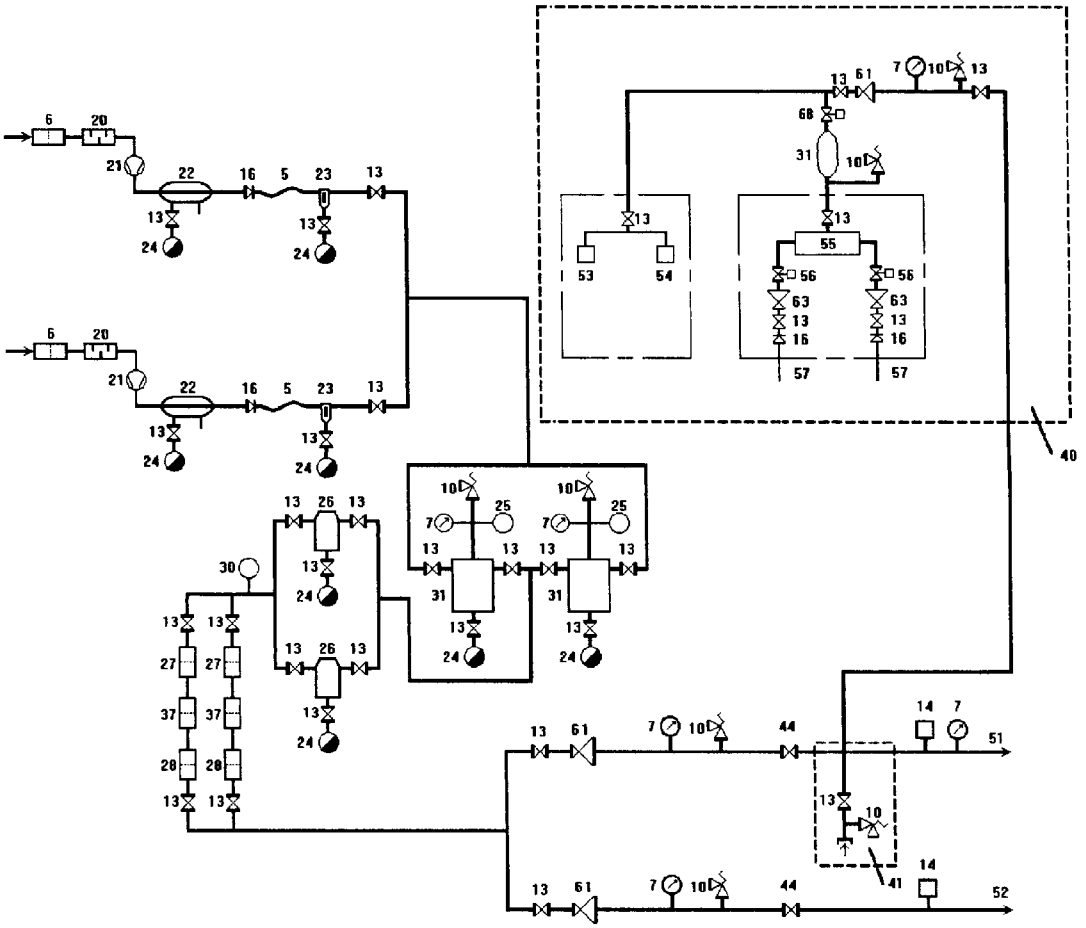


Figure A.12 — Typical source of supply with two air compressor units and one proportioning unit (single stage distribution system)

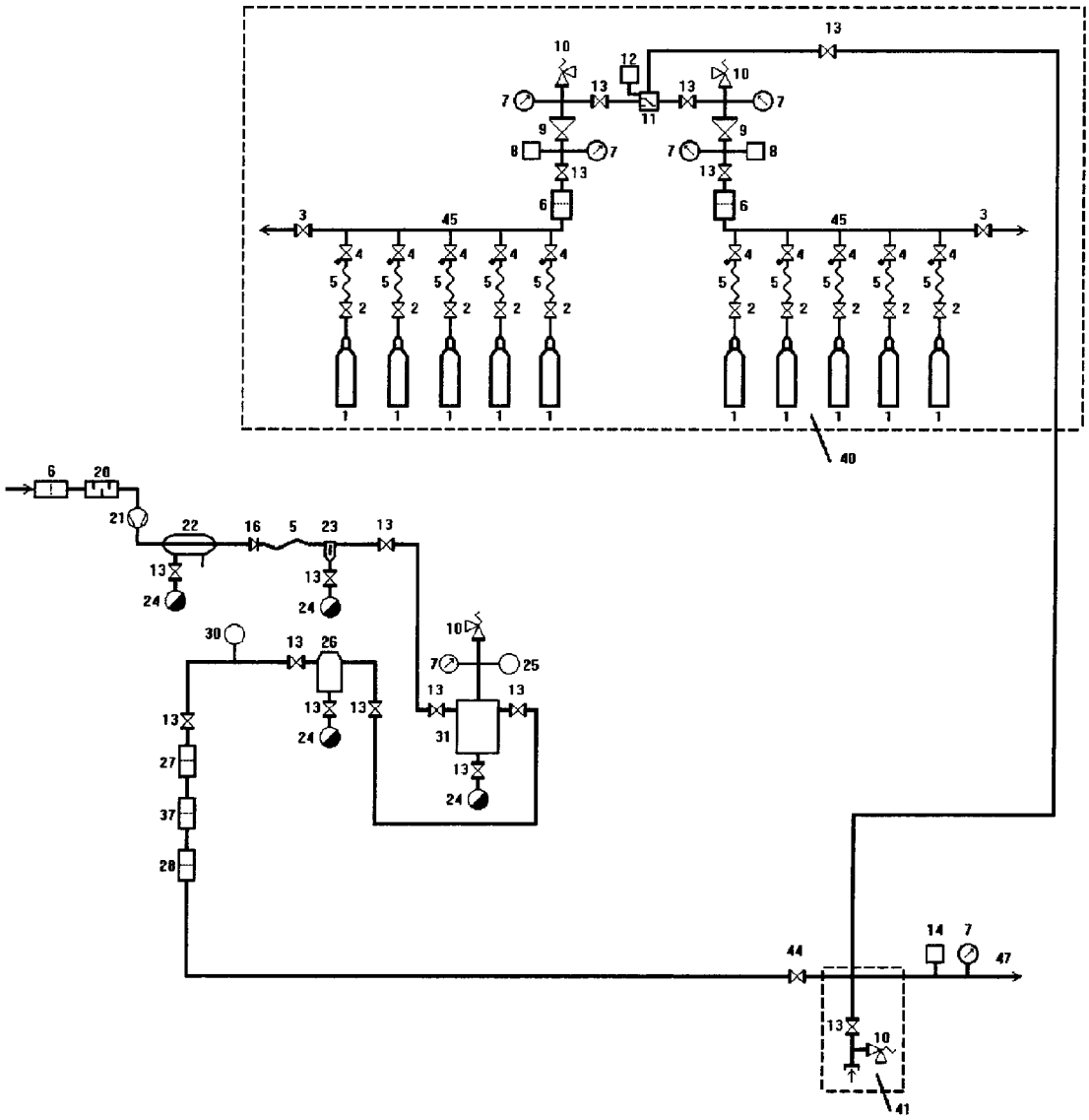


Figure A.13 — Typical source of supply with one air compressor unit and two banks of gas cylinders (double stage distribution system)

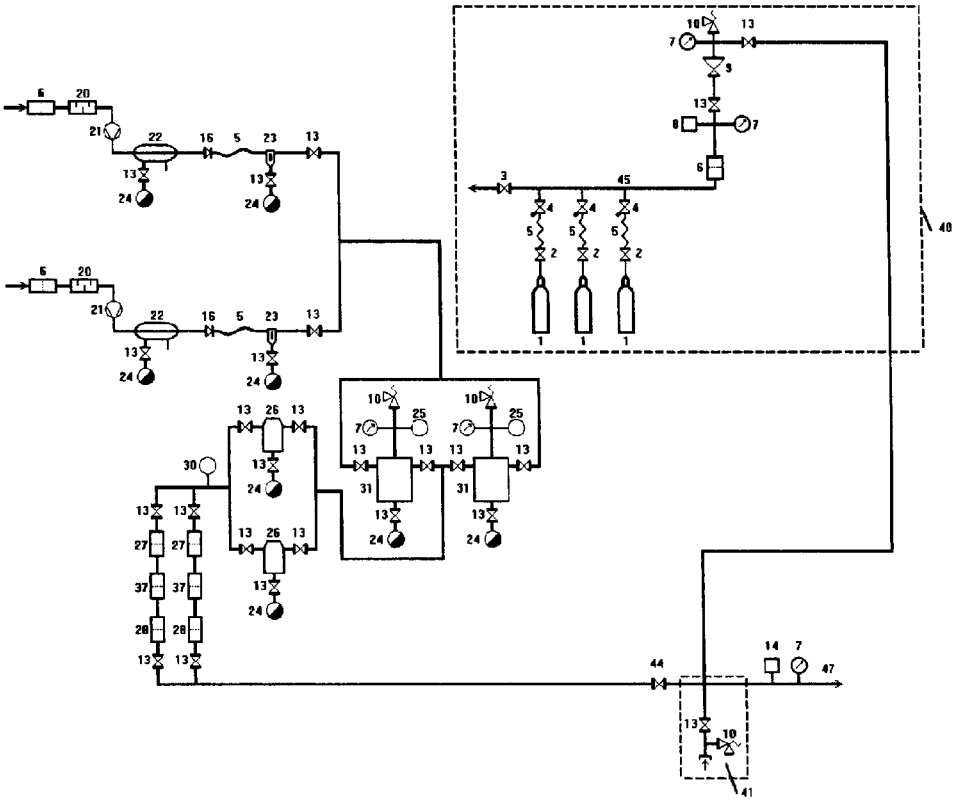


Figure A.14 — Typical source of supply with two air compressor units and one bank of gas cylinders (double stage distribution system)

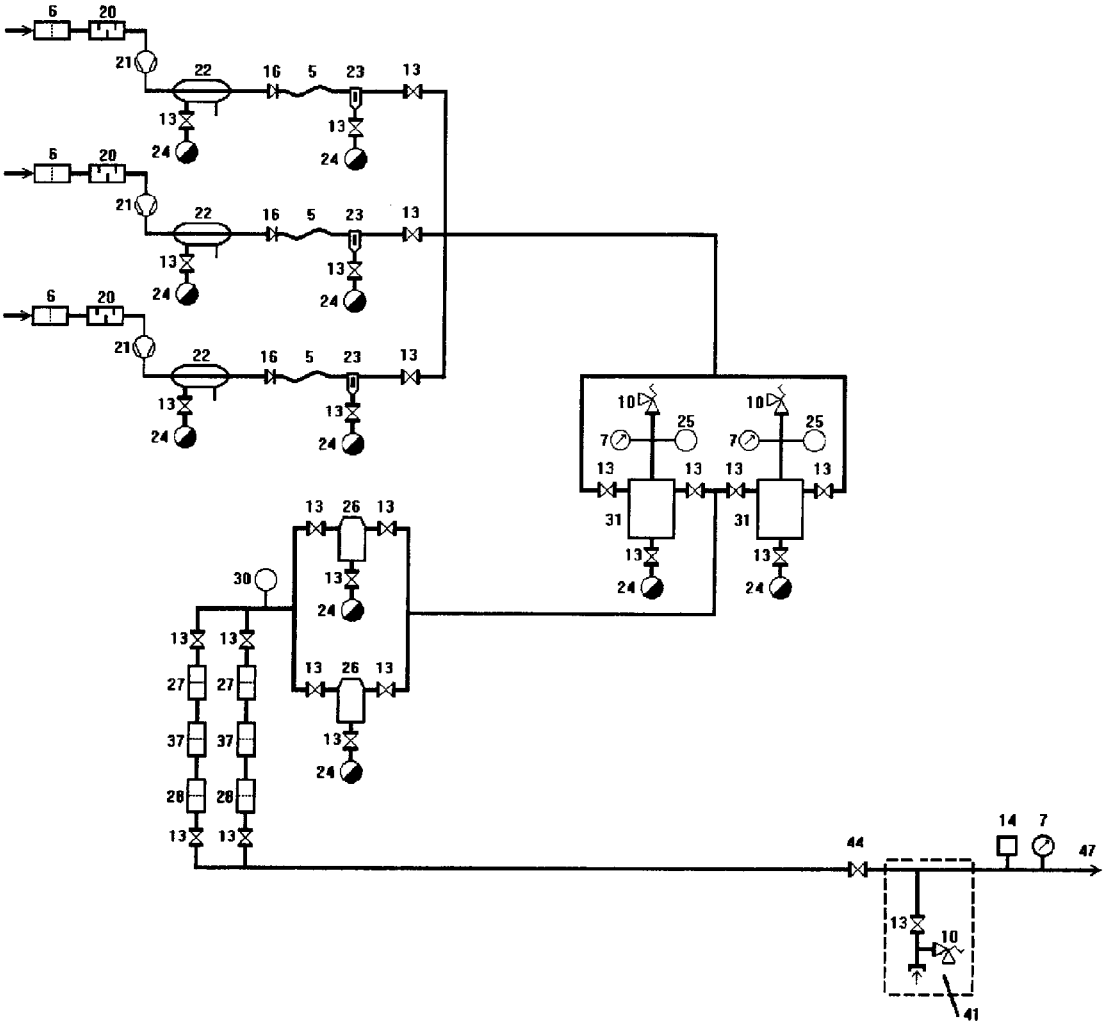


Figure A.15 — Typical source of supply with three air compressor units (double stage distribution system)

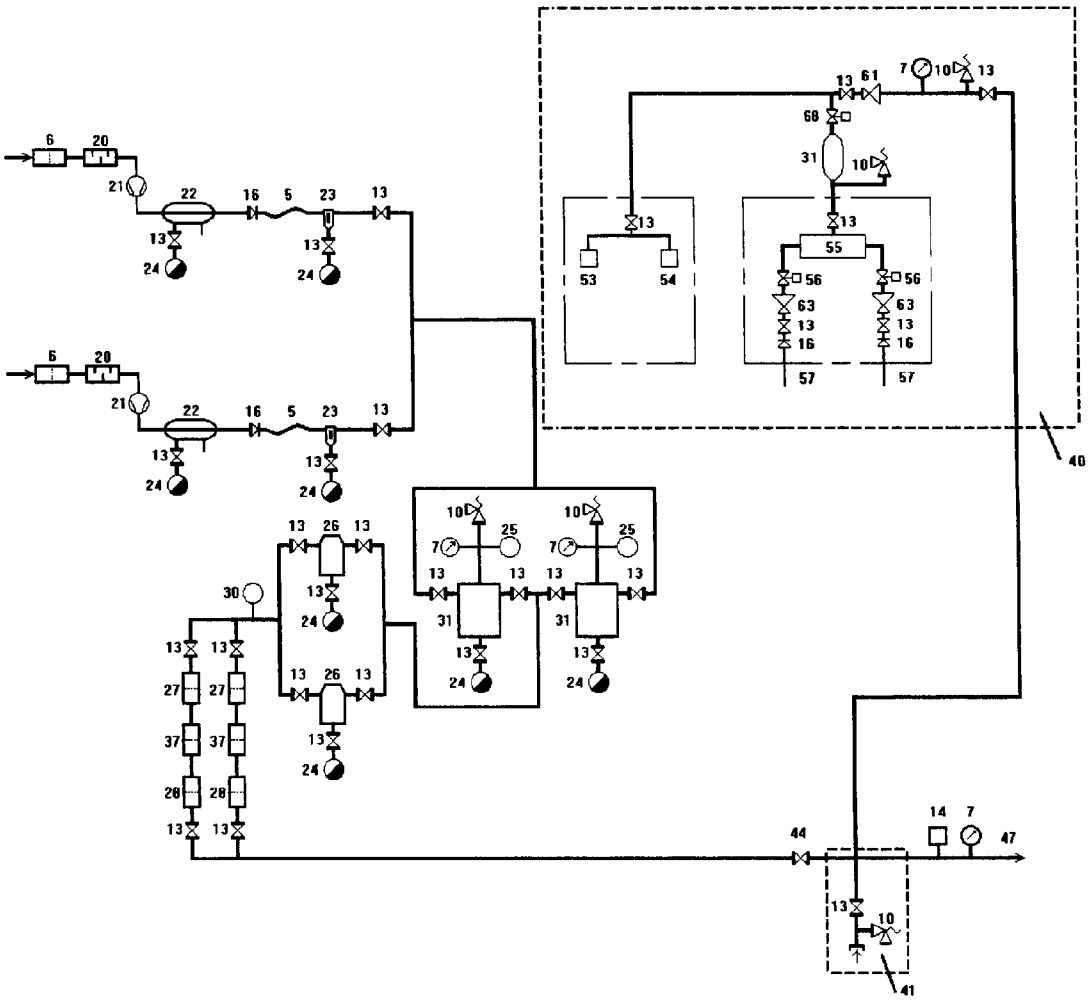


Figure A.16 — Typical source of supply with two air compressor units and one proportioning unit (double stage distribution system)

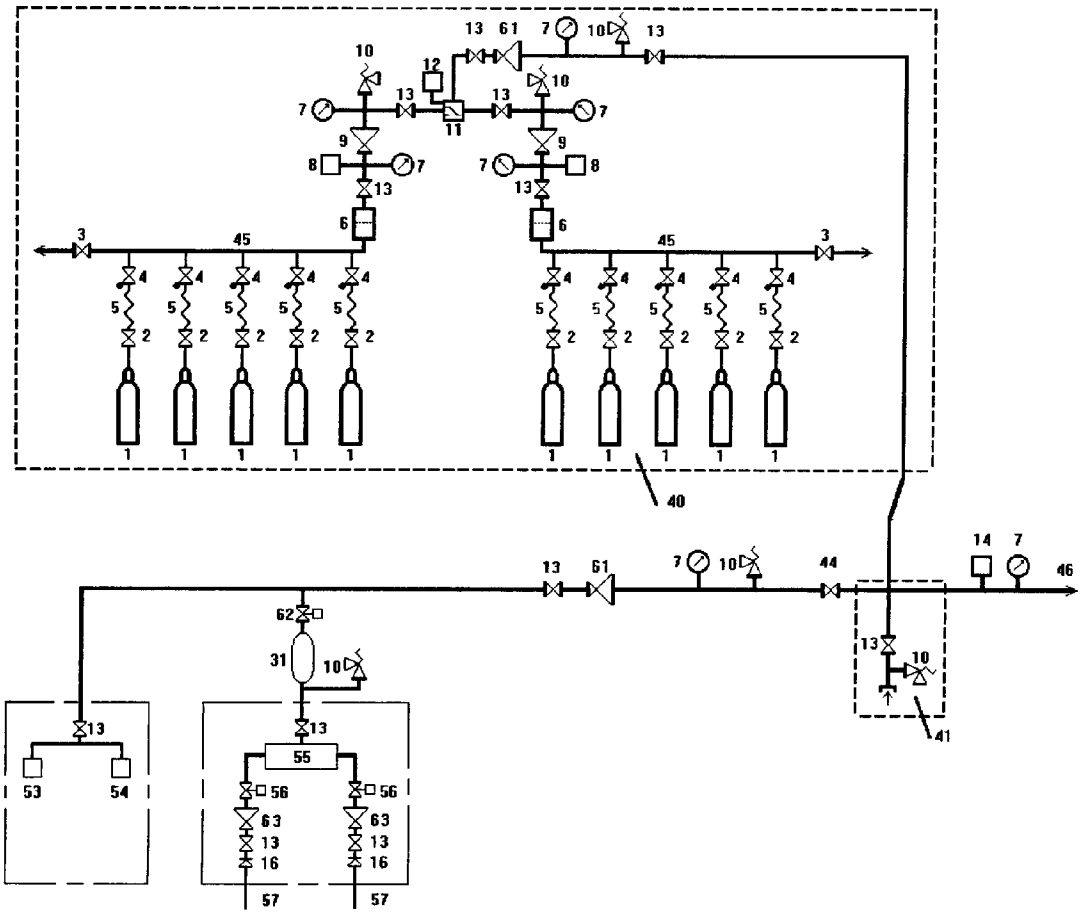


Figure A.17 — Typical source of supply with proportioning system (single stage distribution system)

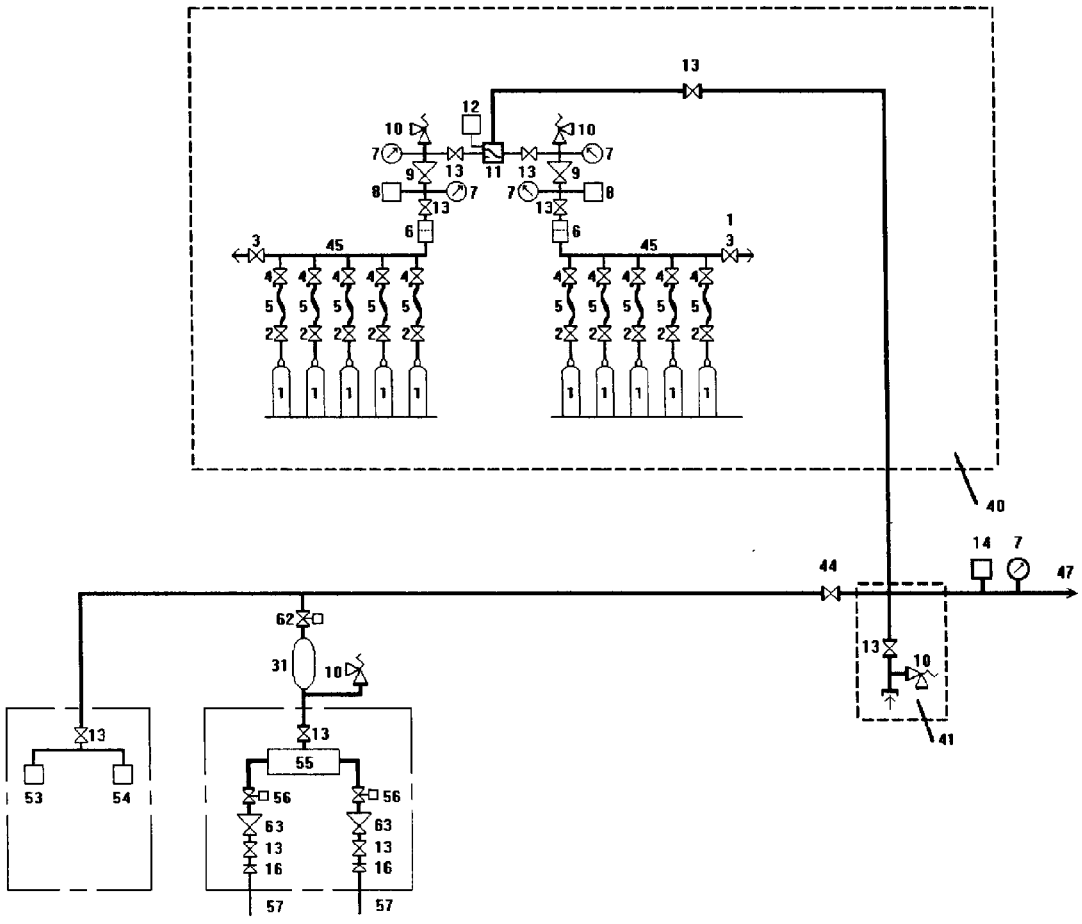


Figure A.18 — Typical source of supply with proportioning system (double stage distribution system)

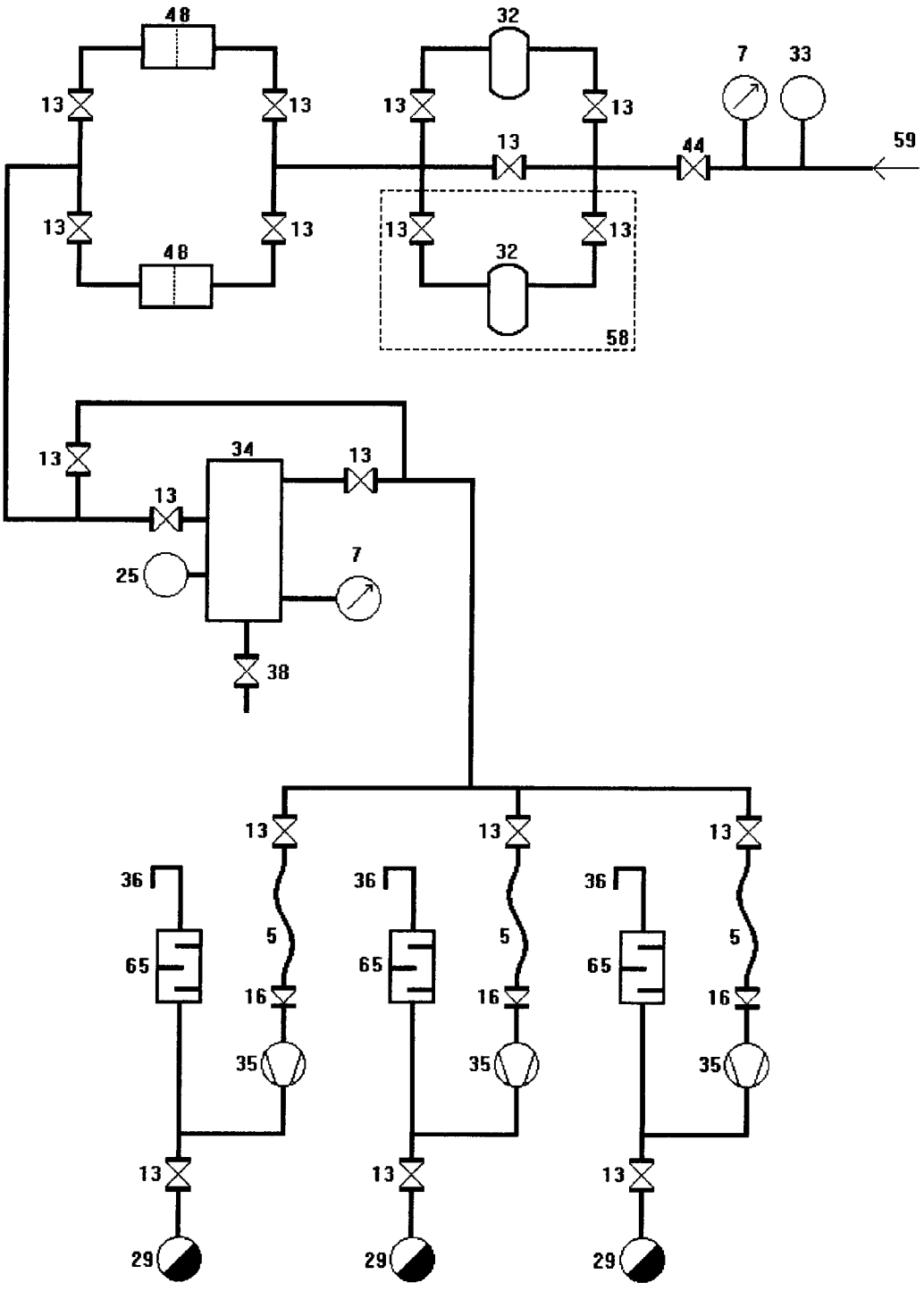


Figure A.19 — Typical source of supply with vacuum pumps

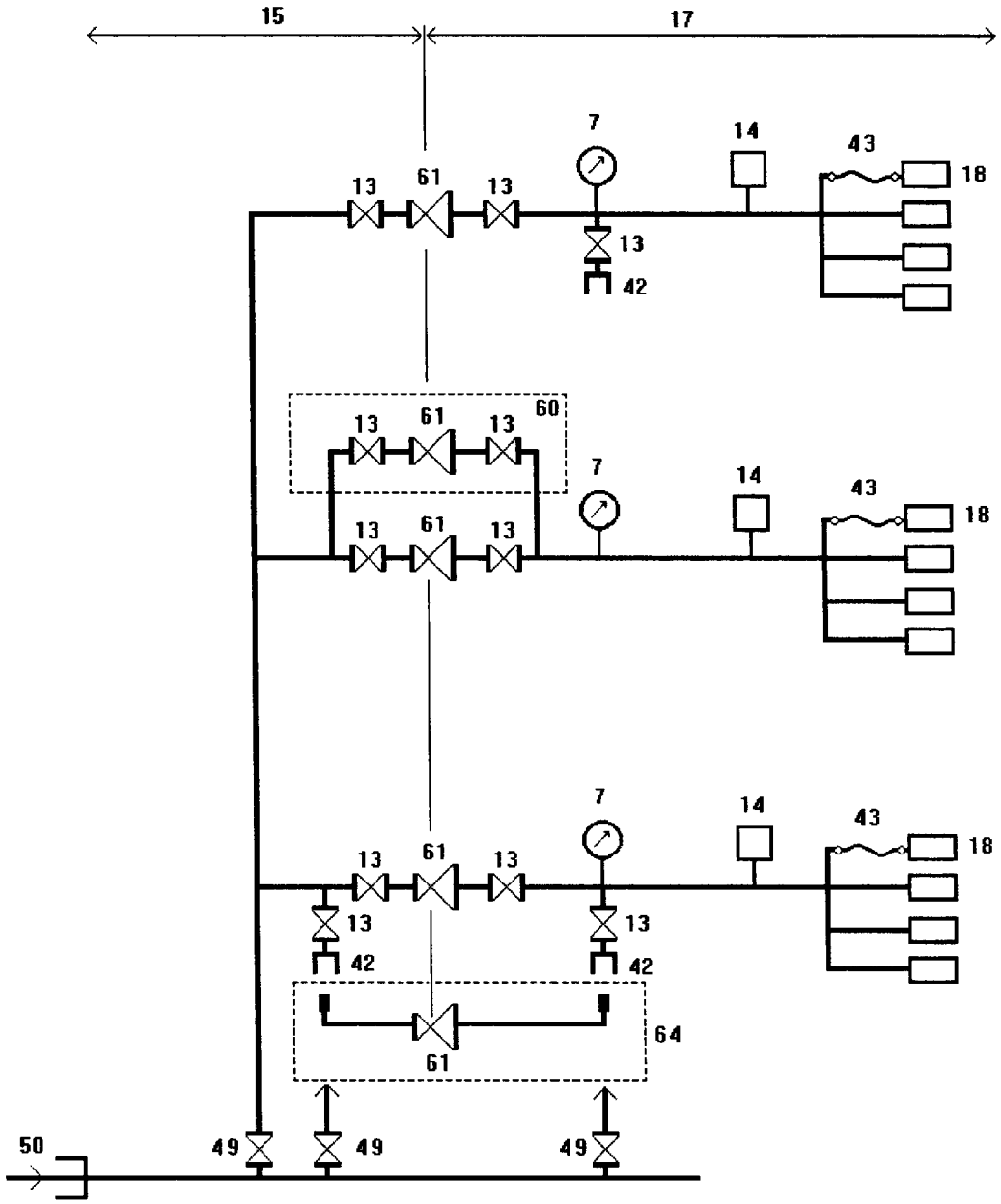


Figure A.20 — Typical double stage distribution system with line pressure regulators within the pipeline system

NOTE Three alternative arrangements in accordance with **5.10** are shown.

Annex B (informative)
Guidelines for location of cylinder manifolds and stationary cryogenic vessels

B.1 Location of cylinder manifolds

A supply system with cylinders should be installed inside a room especially constructed, or suitably modified, well ventilated and fire-resistant. Alternatively, it can be installed in the open air, protected from the weather and the area fenced.

B.2 Location of stationary cryogenic vessels

B.2.1 Stationary cryogenic vessels should not be installed over subterranean structures such as underground bunkers, basement rooms, etc., and should be more than 5 m away from openings to trenches, subterranean structures, manholes, gullies or traps, and at least 3 m from public access routes.

B.2.2 Except for vessels located as given in **B.2.3**, stationary cryogenic liquid oxygen and nitrogen vessels should be installed in a position which is open to the air and at ground level, not on the roof of a building. The control equipment should be protected from the weather and the area fenced.

B.2.3 If a stationary cryogenic vessel is to be installed inside a building, then it should be positioned in a room especially constructed for the purpose with adequate ventilation to the open air in order to avoid the hazards of oxygen enrichment or deficiency. An access door and an emergency exit should be incorporated in this building.

B.2.4 Adequate access for a vehicle should be provided so that a cryogenic liquid supply plant can be filled. The ground in the immediate vicinity of an oxygen filling point should be of concrete or other non-combustible material.

B.2.5 Points of possible escape of gas from pressure-relief valves or bursting discs should be more than 5 m away from public access areas.

Annex C (informative)
Procedure for testing and commissioning

C.1 Introduction

This testing procedure is given as an example of how the specification of clause **12** can be verified so that the system can be commissioned and certified. Other procedures can be devised which validly test this specification. In this procedure the given sequence of tests is important and should be followed.The general requirements of **12.2** should be followed.

Typical forms for certification of the system are given in annex J. A summary of the tests required which lists the specification, procedure and form for each test is given in Tables C.1 and C.2.

C.2 Tests after installation of pipeline systems with at least the base blocks of all terminal units fitted but before concealment (see **12.2.1**).

C.2.1 *Test for mechanical strength*

C.2.1.1 *General*

This test can be carried out on sub-sections of the pipeline, provided that no part of the system is omitted. More than one pipeline can be tested at the same time and for this purpose the pipelines can be linked.

C.2.1.2 *General conditions*

The section to be tested should be completely installed and fixed to the wall. The base blocks of all terminal units should be fitted and blanked. Other devices such as pressure-relief valves, gauges and pressure switches need not be fitted. All connectors for such devices should be blanked.

If separate sub-sections are tested, each section should be isolated from the remainder of the system.

C.2.1.3 *Procedure*

Connect a suitable pressure measuring device to the section under test. Fill the section(s) to be tested with test gas at a pressure of 1,2 times the maximum pressure specified in **12.3.1** for that section. After a period of 15 min check that the system has not ruptured.

> WARNING Precautions should be taken to avoid hazard to personnel arising from possible rupture of the pipeline.

C.2.1.4 *Results*

Record the results on form J1.

C.2.2 ***Test for leakage***

C.2.2.1 *General*

This test can be carried out on sub-sections of the pipeline, provided that no part of the system is omitted. More than one pipeline can be tested at the same time and for this purpose the pipelines can be linked.

C.2.2.2 *General conditions*

The section to be tested should be completely installed and fixed to the wall. The base blocks of all terminal units should be fitted and blanked. Other devices such as pressure-relief valves, gauges and pressure switches need not be fitted. All connectors for such devices should be blanked.

If separate sub-sections are tested, each section should be isolated from the remainder of the system.

C.2.2.3 *Procedure*

Connect a suitable pressure measuring device to the section under test. Fill the section(s) to be tested with test gas at a pressure at least 1,5 times the nominal distribution pressure for compressed medical gas pipelines and 500 kPa for vacuum pipelines. Disconnect and remove the test gas supply. Record the pressure and room temperature initially and again at the end of the test period (2 h to 24 h).

The rate of pressure drop during the test shall be less than 0,025 %/h except for pressure changes due to temperature variations.

> NOTE The pressure change due to temperature variation is approximately 0,35 %/°C (see annex D).

C.2.2.4 *Results*

Record the results on form J1.

C.2.3 *Test for cross-connection and obstruction*

NOTE This test should be carried out on one pipeline at a time and, if possible, on all pipelines within a short period. It is also advisable to check the cleanliness of the pipeline during these tests by suitable observation.

C.2.3.1 *General conditions*

Any links between the systems should be removed before this test is carried out. All pipelines should be at atmospheric pressure and all shut-off valves should be open. A single pressure source should be used and connected to only one system at a time which should remain at working pressure throughout the test. At least one base block on each of the other systems should be open to atmosphere.

C.2.3.2 *Procedure*

C.2.3.2.1 Test each terminal unit on the system under test by opening the base block to its maximum and permitting the test gas to flow for approximately 1 min. Check the gas flow and cleanliness and then re-blank the base block. Remove the pressure source after the last opening has been closed again and leave the connection point open.

C.2.3.2.2 Connect the pressure source to the next gas system and repeat the procedures given in **C.2.3.2.1**. There should be an adequate flow of test gas from every base block on the system under test and no flow from those base blocks left open on other systems. The test gas should be observed to be free from particulate matter (see **C.3.11**).

NOTE 1 After completion of all tests, re-blank all terminal unit base blocks. It is advantageous to leave the piping systems under pressure after these tests are completed. If this is not done, and there is a lapse of time, a retest for leakage should be carried out before final installation of the terminal unit sockets.

NOTE 2 If the flow is too low, there is an obstruction in the piping system which should be remedied.

NOTE 3 If there is no flow from a terminal unit, that terminal unit is wrongly connected or totally obstructed. This situation should be investigated and rectified and the terminal unit re-tested.

NOTE 4 If there is flow from the open base block on a system not under test, that system is cross-connected with the one under test. This should be investigated, rectified and re-tested.

C.2.3.3 *Results*

Record the results on form J2.

C.2.4 *Inspection of marking and pipeline supports*

C.2.4.1 *Procedure*

Visually inspect that marking has been correctly placed on all pipelines especially adjacent to T-connections and where pipelines pass through wall partitions. Check the pipeline supports. Check that all items installed at this stage comply with the design specification.

The marking should be in accordance with clause **10**. The pipeline supports should be in accordance with **11.2**.

C.2.4.2 *Results*

Record the results on form J1.

C.3 Tests and procedures after complete installation and before use of the system (see 12.2.2)

C.3.1 *Test for leakage from compressed medical gas pipelines*

NOTE All pipelines can be tested at the same time. These tests can be carried out on sections of each pipeline provided that no section is omitted.

C.3.1.1 *General conditions*

The leakage test described in **C.2.2** should have been completed satisfactorily. All terminal units, valves, gauges and pressure sensors should be fitted. The source of supply should be isolated from the pipeline. There should be no links between the pipeline systems.

C.3.1.2 *Procedure*

Connect a suitable pressure measuring device to the system(s) under test. Fill the system(s) under test with test gas at nominal distribution pressure. This filling procedure can also be used to measure the volume of the pipeline (see annex E). Disconnect and remove the gas supply. Record the pressure initially and again at the end of the test period.

The rate of pressure drop during the test period should not exceed the value specified in the formula given in **12.4.1.1**.

C.3.1.3 *Results*

Record the results on form J3.

C.3.2 *Test for leakage into vacuum pipelines*

C.3.2.1 *General conditions*

The leakage test described in **C.2.2** should have been completed satisfactorily. All terminal units, valves and other devices such as gauges and pressure switches should have been installed.

The vacuum supply system should be connected to the system under test.

C.3.2.2 *Procedure*

Connect a vacuum gauge to the system. Operate the vacuum supply system until the nominal distribution pressure (see Table 3) is achieved. With the system at nominal distribution pressure, isolate the vacuum supply system. Record the vacuum shown on the vacuum gauge initially and after 1 h.

The pressure increase after 1 h should not exceed 20 kPa.

C.3.2.3 *Results*

Record the results on form J4.

C.3.3 *Test for leakage and check of shut-off valves for closure, zoning and identification*

NOTE This test can be carried out on more than one system at a time. The leakage test is not necessary on vacuum systems.

C.3.3.1 *General conditions*

The tests given in **C.3.1** should have been completed satisfactorily and all terminal units should be closed.

C.3.3.2 *Procedure*

C.3.3.2.1 Connect a pressure measuring device to the remote part of the system. The system should be at nominal distribution pressure with all shut-off valves closed.

C.3.3.2.2 Depressurize the pipeline system downstream of the most remote valve from the source of supply to 100 kPa by opening a terminal unit. Close the terminal unit.

C.3.3.2.3 Note the total number of terminal units controlled by the shut-off valve and check that these terminal units are correctely labelled and that they are all at the test pressure of 100 kPa.

C.3.3.2.4 If necessary, readjust the pressure to 100 kPa. Read the pressure in the section under test and then read the pressure again after 15 min.

C.3.3.2.5 On each system open the shut-off valves in sequence towards the source of supply, repeating procedures **C.3.3.2.2**, **C.3.3.2.3** and **C.3.3.2.4**.

C.3.3.2.6 On compressed medical gas pipeline systems the pressure increase downstream of the valve under test should not exceed 5 kPa after 15 min. Each valve should serve only the areas intended by the system design.

C.3.3.3 *Results*

Record the results on form J5.

C.3.4 ***Test for cross-connection***

NOTE These tests can be carried out in association with the test for obstruction (see **C.3.5**).

C.3.4.1 *General conditions*

In no circumstances should these tests be carried out on more than one pipeline system at a time.

All pipeline systems should be at atmospheric pressure and all shut-off valves open. A single pressure source should be used and connected to only one pipeline system at a time which should remain at nominal distribution pressure throughout the test. In the case of the vacuum pipeline system, the vacuum supply source should be used. These tests should be applied to all terminal units.

C.3.4.2 *Procedure*

C.3.4.2.1 Pressurize (or evacuate) the pipeline system to be tested at nominal distribution pressure.

C.3.4.2.2 Check that gas flows through every terminal unit of the pipeline system under nominal distribution pressure.

C.3.4.2.3 Check that there is no gas flow through all terminal units of the other pipeline systems when they are opened with gas-specific probes.

C.3.4.2.4 There should be no cross-connections.

C.3.4.3 *Results*

Record the results on form J6.

C.3.4.4 With all the other pipeline systems at atmospheric pressure repeat the procedure in **C.3.4.2** on each pipeline system in turn, including vacuum, preferably at one session and record the results on form J6.

C.3.4.5 Repeat the test in full if any modifications are made to the pipeline systems during the commissioning procedure and record the results on form J6.

C.3.5 ***Test for obstruction and check of terminal units and NIST connectors for mechanical function, gas-specificity and identification***

NOTE These tests can be carried out at the same time as the cross-connection test described in **C.3.4**. In this case only one pipeline system at a time is under pressure. Alternatively, after the completion of the tests given in **C.3.4**, all pipeline systems can be pressurized and the tests described in **C.3.5** can be carried out simultaneously.

C.3.5.1 *General conditions*

The accuracy of the test equipment should be checked before commencing the test procedure. All terminal units should be complete with fascia plate.

C.3.5.2 *Procedure*

C.3.5.2.1 Insert a gas-specific test probe with gauge and flow measuring device into each terminal unit in turn. Check that the pressure drop at each terminal unit does not exceed the value given in Table 5 at the specified flow.

C.3.5.2.2 Check that the gas-specific probe can be easily inserted, captured and released. If an anti-swivel device is provided, check that this retains the probe in the correct orientation.

C.3.5.2.3 Check that no gas is released at each terminal unit by the probes of all other gases and that no probes can be captured.

C.3.5.2.4 Check that all NIST connectors accept the appropriate NIST nipples and that a mechanical connection is made. Check that the NIST nipples for all other gases do not fit the connectors under test.

C.3.5.2.5 All terminal units should be identified and labelled and should function correctly in accordance with the requirements specified in **12.4.5**.

C.3.5.3 *Results*

Record the results on forms J7 and J8.

C.3.6 *Test of system performance*

C.3.6.1 *General conditions*

These tests should be carried out on one system at a time. All shut-off valves should be open. Connect a supply of test gas at the supply source of sufficient capacity to deliver the system design flow for several minutes. The vacuum supply system can be used to test the vacuum pipeline system.

C.3.6.2 *Procedure*

C.3.6.2.1 Pressurize or evacuate the pipeline at a pressure not greater than the maximum distribution pressure or vacuum.

Record the pressure.

C.3.6.2.2 Insert a probe with a calibrated orifice into selected terminal units throughout the pipeline under test to provide a total flow equal to the system design flow.

C.3.6.2.3 Observe and record the gauge pressure at the specified flow at selected terminal units throughout the pipeline system. The selected terminal units should be remotely located (e.g. at the end of each branch).

C.3.6.2.4 The change in pressure at each of the selected terminal units should be within the limits for distribution pressure given in Table 1.

C.3.6.2.5 Depressurize the system and repeat the test for each gas service.

C.3.6.3 *Results*

Record the results on form J9.

NOTE Remedial work can be needed if these values are not met.

C.3.7 *Test of pressure-relief valves*

C.3.7.1 *General conditions*

If type-tested and certified pressure-relief valves are installed, tests of relief valve function are not required; in this case proceed as described in **C.3.7.2.1** to **C.3.7.2.3**.

If the pressure-relief valves fitted are not type-tested or certified, their performance should be verified according to the procedure given in **C.3.7.2.3** to **C.3.7.2.7**.

C.3.7.2 *Procedure*

C.3.7.2.1 Inspect each pressure-relief valve to check the discharge capacity and the set pressure.

C.3.7.2.2 Inspect the certification supplied with each pressure-relief valve.

C.3.7.2.3 Inspect the installation of the pressure-relief valves to ensure that they are correctly vented.

C.3.7.2.4 Isolate a section of pipeline in which the pressure-relief valve to be tested is located.

C.3.7.2.5 Gradually increase the pressure in this section of the pipeline and note the pressure at which the pressure-relief valve lifts and at which pressure it gives a full discharge.

C.3.7.2.6 Reduce the pressure to nominal distribution pressure and note the value at which the pressure-relief valve re-seats and is gas tight.

C.3.7.2.7 The pressure at which the pressure-relief valves operate should permit the system to meet the requirements of **5.1.6** and **5.1.7**.

C.3.7.3 *Results*

Record the results on form J10.

C.3.8 ***Functional tests of all sources of supply***

C.3.8.1 *General conditions*

All sources of supply should be installed and connected to normal and stand-by power supplies. Specific check lists for each supply system should have been prepared to meet the requirements of clause **5** and the manufacturer's specifications.

C.3.8.2 *Procedure*

All pipeline joints should be tested for leakage at nominal distribution pressure. The compressor plant should be tested for leaks during normal running. Minor leaks detectable as bubbles are acceptable. The function and operating parameters of each supply system should be checked from the list. The supply system should be shown to operate on the stand-by power supply.

The test results should conform to the manufacturer's specifications and the requirements of clause **5**. It should be confirmed that the manufacturer's specifications meet the system design flow requirements of the pipelines.

C.3.8.3 *Results*

Record the results on form J11.

C.3.9 ***Tests of control, monitoring and alarm systems***

C.3.9.1 *General conditions*

These tests should be carried out for one function at a time on one system at a time. All alarm systems should be fully installed and in operation.

C.3.9.2 *Procedure*

C.3.9.2.1 All alarm sensors should be shown to operate with an appropriate change in the local system condition (for example pressure, moisture content, liquid level, system change-over). Record the settings at which alarm sensors switch on and off.

C.3.9.2.2 Observe all alarm functions, such as visual and auditory signals, resetting of the auditory signal and lamp test. Check that the visual and auditory characteristics of the signals are in accordance with clause **6**, if applicable.

C.3.9.2.3 All monitors and alarms should operate with the appropriate changes in pipeline system condition.

C.3.9.2.4 All monitoring and alarm signals should comply with the requirements of clause **6** and should operate from the normal and emergency electrical power supplies.

C.3.9.3 *Results*

Record the results on form J12.

C.3.10 ***Purging with test gas***

> NOTE This procedure can be carried out immediately after the system performance test given in **C.3.6** and can also be combined with the test for particulate matter given in **C.3.11**.

C.3.10.1 *General conditions*

The test described in **C.3.6** should have been satisfactorily completed. A source of air or nitrogen from cylinders should be connected to the pipeline at the emergency and maintenance inlet.

C.3.10.2 *Procedure*

Open each terminal unit in turn and purge with air or nitrogen at a flow of about 150 l/min in sufficient volume to remove particulate matter from the pipeline. Check that each terminal unit is free from particulate matter. A suitable test device for this purpose is shown in Figure 1.

The manufacturer should use the same test device as the testing authority.

C.3.10.3 *Results*

Record the results on form J13.

C.3.11 ***Test for particulate contamination of the pipelines***

C.3.11.1 *General conditions*

The pipeline systems should be at nominal distribution pressure and filled with the test gases.

C.3.11.2 *Procedure*

The most distant terminal unit on each branch of the pipeline should be tested with the membrane filter device described in Figure 1 at a flow of 150 l/min for 15 s. At least 20 % of the terminal units on each system should be tested for particulate contamination.

The filters should be free from particulate matter when viewed in good light.

C.3.11.3 *Results*

Record the results on form J14.

C.3.12 ***Filling with specific gas***

NOTE All systems can be filled with their specific gases at the same time.

C.3.12.1 *General conditions*

All previous tests should have been satisfactorily completed. Sources of test gas should be disconnected. Each pipeline system should be connected to its source of supply with all shut-off valves open. All special connectors should be removed from site. All pipeline systems should be at atmospheric pressure.

C.3.12.2 *Procedure*

C.3.12.2.1 Fill the pipeline system to be tested from its source of supply to the nominal distribution pressure or vacuum.

C.3.12.2.2 Except for vacuum pipelines, allow a flow of gas from each terminal unit in turn. Close the main shut-off valve and allow the pressure in each pipeline to fall to atmospheric.

NOTE Oxygen and nitrous oxide should be vented outside the building.

C.3.12.2.3 Open the main shut-off valve and refill each pipeline to the nominal distribution pressure.

Repeat the procedure given in **C.3.12.2.2** as many times as are required to give a gas concentration which conforms with the requirements of **12.4.14**.

C.3.12.2.4 Leave each pipeline system at nominal distribution pressure with the source of supply connected.

For vacuum systems **C.3.12.2.2** is not applied.

C.3.12.3 *Results*

Record on form J15 that all pipeline systems are filled with the specific gas.

C.3.13 ***Test of purity of air produced by compressor systems***

Not used.

C.3.14 ***Test for gas identity***

C.3.14.1 *General conditions*

The pipeline systems should be at nominal distribution pressure and filled with the specific gases. All pipeline systems should be tested at the same time. No medical equipment should be connected to the pipeline systems. All other tests in **C.3** should have been satisfactorily completed before this test begins.

C.3.14.2 *Procedure*

All terminal units should be tested as follows:

a) for pipeline installations in which each pipeline system contains a gas with different percentage of oxygen [e.g. O_2 = 100 % (*V/V*); O_2/N_2O mixture, O_2 = 50 % (*V/V*); air for breathing, O_2 = 21 % (*V/V*); N_2O, O_2 = 0 % (*V/V*)], an oxygen analyser can be used as a means of identification by measuring the oxygen concentration at each terminal unit;

b) for pipeline installations in which some pipeline systems contain gases with the same percentage of oxygen (e.g. N_2O, CO_2 and nitrogen for driving surgical tools, or air for breathing and air for driving surgical tools), these systems can be identified by other means such as setting each system to a different pressure and measuring the static pressure at each terminal unit. Following such a procedure, the pressures will have to be reset to the nominal distribution pressure for each system.

C.3.14.3 *Results*

Record the results on form J17.

Table C.1 — Summary of tests required: pipeline with terminal unit base blocks

Test no.	Description	Specification clause of this standard	Procedure clause of this standard	Form
1	Mechanical strength	**12.3.1**	**C.2.1**	J1
2	Leakage	**12.3.2**	**C.2.2**	J1
3	Cross-connection and obstruction	**12.3.3**	**C.2.3**	J2
4	Marking and supports	**12.3.4**	**C.2.4**	J1

Table C.2 — Summary of tests required: complete installation

Test no.	Description	Specification clause of this standard	Procedure clause of this standard	Form
5	Compressed gas leakage	12.4.1.1	C.3.1	J3
6	Vacuum leakage	12.4.1.2	C.3.2	J4
7	Shut-off valves leakage	12.4.1.3	C.3.3	J5
8	Shut-off valves	12.4.2	C.3.3	J5
9	Cross-connections	12.4.3	C.3.4	J6
10	Obstructions	12.4.4	C.3.5	J7
11	Terminal units	12.4.5	C.3.5	J7
12	NIST connectors	12.4.5	C.3.5	J8
13	System performance	12.4.6	C.3.6	J9
14	Pressure-relief valves	12.4.7	C.3.7	J10
15	Sources of supply	12.4.8	C.3.8	J11
16	Monitoring and alarm systems	12.4.9	C.3.9	J12
17	Purging with test gas	12.4.10	C.3.10	J13
18	Particulate contamination	12.4.11	C.3.11	J14
19	Filling with specific gas	12.4.12	C.3.12	J15
20	Not used	Not used	Not used	Not used
21	Gas identity	12.4.14	C.3.14	J17
	Construction labels removed	12.5.3		

Annex D (informative)
Temperature and pressure relationships

D.1 Example of corrections of the pressure drop for variations due to temperature according the ideal gas law

From the ideal gas law:

$$PV = nRT$$

i.e.

$$P_2/T_2 = P_1/T_1 \text{ and}$$

$$P_2 = P_1T_2/T_1$$

where

P_1 = initial pipeline absolute pressure
P_2 = final pipeline absolute pressure
T_1 = initial pipeline absolute temperature
T_2 = final pipeline absolute temperature
V = volume of the pipeline

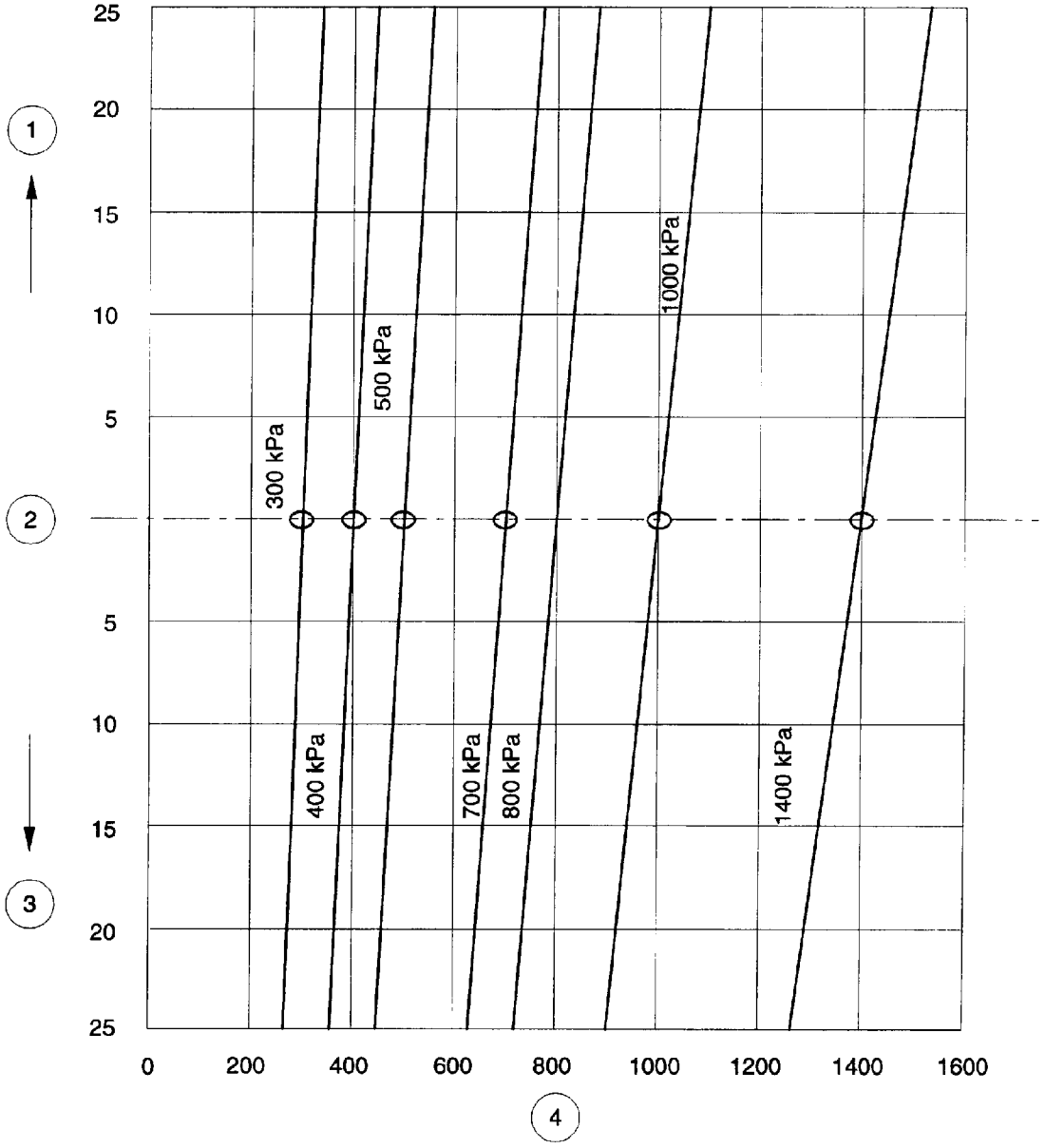
NOTE 1 Absolute pressure = gauge pressure + 100 kPa.

NOTE 2 The relationship between temperature and pressure at typical pipeline pressures is shown in Figure D.1.

NOTE 3 An example of correction using the diagram in Figure D.1 is:

The pressure of a system previously at 1 400 kPa and 20 °C will fall to about 1 350 kPa with a 10 °C fall in temperature. This may be confirmed by calculation as follows:

P_1 = 1 500 kPa (1 400 kPa gauge pressure)
T_1 = 293 K (20 °C)
T_2 = 283 K (10 °C)
P_2 = 1 449 kPa (1 349 kPa gauge pressure)



1) Increase
2) Temperature change (°C)
3) Decrease
4) Gauge pressure (kPa)

Figure D.1 — Relationship between temperature and pressure at typical pipeline pressures

Annex E (informative)
Method for measuring pipeline volume

E.1 Apparatus

E.1.1 *Full gas cylinder*, of known water capacity with a gas content of not more than 5 times the estimated volume of the system to be measured.

E.1.2 *Pressure regulator*, with a 100 mm nominal size (diameter) high pressure gauge.

E.1.3 *Low pressure gauge*, with a 100 mm nominal size (diameter) with a full scale reading not more than 3 times the nominal distribution pressure. This gauge can be mounted on the regulator.

E.2 Procedure

E.2.1 Fit the pressure regulator onto the cylinder and connect the regulator outlet to the pipeline. Read on the high pressure gauge the initial pressure of the cylinder.

E.2.2 Connect the low pressure gauge to the pipeline and check that the pipeline is at atmospheric pressure.

E.2.3 Fill the pipeline to nominal distribution pressure. Record the pressures on the high pressure gauge and on the low pressure gauge.

E.3 Results

From the ideal gas law:

$$PV = nRT$$

i.e.

$$P_1V_1 + P_2V_2 = P_3V_1 + P_4V_2 \text{ and}$$

$$V_1(P_1 - P_3) = V_2(P_4 - P_2)$$

$$V_2 = V_1(P_1 - P_3)/(P_4 - P_2)$$

where

P_1 = initial cylinder absolute pressure
P_2 = initial pipeline absolute pressure
P_3 = final cylinder absolute pressure
P_4 = final pipeline absolute pressure
V_1 = volume (water capacity) of the cylinder
V_2 = volume of the pipeline

NOTE Absolute pressure = gauge pressure + 100 kPa.

Annex F (informative)
Guidelines for general requirements for supply plants

F.1 Rooms or areas for supply systems should not be used for any purpose other than for supply plant equipment containing the gases that are to be distributed through the pipelines, except that empty cylinders disconnected from the supply equipment can be stored, pending their removal. In addition, one group of filled cylinders sufficient for one side of the manifold can be stored in the same room or area. A separate storage area should be provided for empty cylinders.

F.2 Only nominated persons should be authorized to operate and attend the plant.

F.3 Services containing combustible gases or liquids should not be permitted within any manifold room or source of supply area.

F.4 Any heating system can be used to heat supply plant enclosures or storage areas, provided that no part of the heating system in contact with the air within the room exceeds a temperature of 225 °C and that the supply plant or cylinders are prevented from coming in direct contact with the heating system.

F.5 All electrical fittings in supply rooms should be located in fixed positions to minimize the risk of physical damage.

F.6 Fire fighting equipment should be provided.

F.7 The room or enclosure should be well ventilated to the open air, and ducting for such ventilation should not be connected to that serving any other building.

F.8 The doors or gates provided to facilitate cylinder handling or plant filling should be capable of being locked. An emergency exit should be provided which should be free from obstructions at all times. All doors should be capable of being opened from the inside, at any time, without a key. All doors should open outwards.

F.9 Enclosures (interior or exterior) for supply system should conform to the following requirements:

e) when enclosures are located near sources of heat such as furnaces, incinerators or boiler rooms, construction should prevent cylinder temperature from exceeding 50 °C;

f) enclosures should not be located within 3 m of open electrical conductors and transformers;

g) enclosures should not be located adjacent to oil storage tanks;

h) enclosures should comply with local building codes;

i) enclosures should have concrete floors;

j) a warning notice should be clearly displayed on both sides of each door or gate, for example:

"Warning: oxygen/nitrous oxide" (or chemical symbols, etc., as appropriate)

"No smoking"

"No open flames or sparks"

"No oil or grease"

"No combustible material to be placed within 5 m"

k) fences and walls should be of a height not less than 1,75 m.

F.10 Enclosures should be easily accessible to vehicles delivering cylinders or cryogenic liquid and be at ground level or vehicle height according to the method of unloading used.

F.11 Enclosures should be located so that no part of the enclosure is less than 5 m (for stationary oxygen cryogenic vessels) or 3 m (for other supply plant) from any occupied building or from any roadway or footpath.

Annex G (informative)
Guidelines for emergency procedures

G.1 General

G.1.1 Emergencies can arise which can result in the sudden cessation of the gas supply to one or more clinical areas. Should such failures occur, it is vital that procedures have been set up which can ensure immediate action on:

— communication of the problem to those persons and areas affected;

— conservation of supply;

— remedial actions.

G.1.2 National or local regulations relating to fire precautions should be complied with.

G.2 Communication

G.2.1 Communication procedures should be set up to ensure that any emergency arising is notified immediately to all clinical areas likely to be affected and to all staff involved in the maintenance of gas supplies and in remedial actions.

G.2.2 Such communication should include:

— the nature of the emergency;

— details of the gas conservation procedures to be applied;

— likely duration of the emergency;

— remedial actions to be taken.

G.2.3 Experienced persons should be nominated in each area to coordinate and communicate actions.

G.3 Conservation of supplies

G.3.1 On receiving an emergency notification, the coordinator in each clinical area should reduce the use of gas from the pipeline system(s) involved to the level required and bring into use their own reserves.

G.3.2 The staff responsible should check on reserves available and bring into use as necessary, plant and cylinders on reserve manifolds, emergency pipeline inlets, or at points of use.

G.3.3 If necessary, additional supplies of gas should be ordered from suppliers or from other hospitals to meet the expected duration of the emergency.

G.4 Remedial actions

G.4.1 The cause of emergency failure of supply should be investigated immediately and action initiated to remedy the fault or damage.

G.4.2 Such investigations can show that other areas of the hospital, not initially affected, can need to be isolated to carry out repairs. In this case, communication and conservation procedures should be instituted in these areas before shutting off the gas supply to another system or area.

G.4.3 Remedial work should be carried out under an effective method of control.

G.5 Training

G.5.1 The staff responsible should be properly trained in the use of medical gases and pipeline systems and be fully familiar with their hospital pipeline layout and the location of all zone isolation valves.

G.5.2 Emergency procedures should be initiated at least twice a year as an exercise, and any problem or retraining action noted and followed up.

G.5.3 Actual emergency situations should be evaluated and appropriate action taken to improve procedures and training.

G.6 Nominated staff

Persons should be specifically nominated to attend, operate and maintain plant. They should be appropriately trained and qualified in the handling of cylinders and gas supply plants.

G.7 Reserve supplies

G.7.1 It is recommended that gas reserves in cylinders not normally connected to a source of supply are held in addition to reserves connected to a source of supply. The capacity of such unconnected reserves should be calculated to take into account the normal daily usage of the gas, the normal supply arrangements and the emergency procedures which will be taken in the event of a plant or gas supply failure.

G.7.2 Sufficient cylinders equal to the capacity of one manifold bank can be held in each manifold room. Additional cylinders can be held in an adjacent cylinder store.

G.7.3 Critical care areas can require their own cylinder reserves to minimize any delay in maintaining gas supplies in an emergency. If cylinders with attached regulators are used for this purpose, the regulator outlet should be gas-specific for connection to a low-pressure hose assembly.

G.8 Safety

G.8.1 Suitable handling facilities (e.g. purpose-designed trolleys) should be provided for the movement of cylinders.

G.8.2 Cylinder storage areas should be well ventilated and the cylinders should be stored in accordance with the supplier's recommendations. Full and empty cylinders should be segregated and the respective storage areas should be labelled.

G.8.3 Access to cylinder manifold rooms and storage areas should be level and kept clear. In particular, emergency exits from these rooms and areas should be kept free of obstructions at all times. Emergency exits should lead into the open air or other safe location.

Annex H (informative)
Recommended minimum requirements for the organization of the maintenance

H.1 General

A systematic approach to the maintenance of a medical gas pipeline system is essential. This annex provides information that should be used when setting up a maintenance programme, but does not include actual maintenance tasks or frequencies.

H.2 Organization

H.2.1 *Staff*

Only qualified staff, familiar with the functioning of the equipment and with the proper practices for installation, testing and commissioning of medical gas pipelines should be appointed to supervise and to carry out maintenance work.

H.2.2 *Maintenance programme*

A maintenance programme should be established which includes specified maintenance tasks and their frequency.

This programme should include, as a minimum, the manufacturer's recommendations concerning service and maintenance instructions.

Particular attention should be paid to:

a) performance of the system and its components;

b) leakage;

c) wear and tear;

d) contamination (e.g. of air for breathing supplied by compressor systems);

e) preventive maintenance.

A procedure should be instituted for the immediate reporting of defective or suspect equipment and its prompt repair or replacement.

H.2.3 *Safe practices*

The procedures for maintenance should include proper communications and documented control of the work.

If a maintenance operation involves shutting down parts of a pipeline system:

a) the shut-down should be fully coordinated with the clinical staff in the areas affected;

b) any valve(s) and terminal unit(s) affected should be marked to warn against their use.

If a maintenance operation involves breaking into a pipeline system, further action should be taken:

a) to ensure safe working conditions;

b) to reduce contamination;

c) to purge the system to clear any contamination.

H.3 Documentation

A permanent documentation system should be set up which includes the documents as specified in clause **13**, and this documentation system should be brought up to date when required, and be reviewed once a year.

The results of all tests and observations should be recorded in the documentation system.

H.4 Spare parts

The owner should ensure that spare parts as recommended in the list supplied by the manufacturer are readily available.

H.5 Retesting and recommissioning

Following any maintenance activity the appropriate tests in accordance with clause **12** should be carried out.

Annex J (informative)
Typical forms for certification of the pipeline systems

NOTE This annex gives examples of forms to be completed during testing and commissioning of pipelines for compressed medical gases and vacuum in accordance with annex C.

Medical gas pipeline tests **Form J0 (sheet .... of .... sheets)**

Summary of tests

This is to certify that the following tests have been carried out on the piped medical gas installation at ..... hospital.

Test no.	Description	Form	Test completed satisfactorily on
1	Mechanical strength	J1	
2	Leakage	J1	
3	Cross-connection and obstruction	J2	
4	Marking and supports	J1	
5	Compressed gas leakage	J3	
6	Vacuum leakage	J4	
7	Shut-off valves leakage	J5	
8	Shut-off valves	J5	
9	Cross-connections	J6	
10	Obstructions	J7	
11	Terminal units	J7	
12	NIST connectors	J8	
13	System performance	J9	
14	Pressure-relief valves	J10	
15	Sources of supply	J11	
16	Monitoring and alarm systems	J12	
17	Purging with test gas	J13	
18	Particulate contamination	J14	
19	Filling with specific gas	J15	
20	Not used	Not used	
21	Gas identity	J17	
	Construction labels removed		

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J1 (sheet .... of .... sheets)**

Pipeline with terminal unit base blocks: mechanical strength, leakage, marking and supports

Hospital Scheme

This is to certify that a mechanical strength test in accordance with **C.2.1** and a leakage test in accordance with **C.2.2** have been carried out on the piped ..... system.

During the tests the pressures shown below were observed. Marking and supports have also been inspected in accordance with **C.2.4**.

Medical gas (name)	Section tested	Test pressure	Hours on test h	Pressure drop kPa	Pressure drop %/h	Pass/fail spec. 0,025 %/h	Marking as clause 10	Supports as 11.2	Date

For the purpose of this test the following links were made .....

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Medical gas pipeline tests **Form J2 (sheet .... of .... sheets)**

Pipeline with terminal unit base blocks: cross-connection and obstruction test

Hospital Scheme

This is to certify that a cross-connection and obstruction test in accordance with **C.2.3** has been carried out as follows.

Medical gas (name)	Location	Date of Test

No cross-connections or obstructions were found between these systems.

Contractor's representative

Status Signed
Date Name

Medical gas pipeline tests **Form J3 (sheet .... of .... sheets)**

Complete installation: compressed gas leakage tests

Hospital Scheme

This is to certify that a leakage test in accordance with **C.3.1** has been carried out on the following pipeline system.

Medical gas (name)	**Section tested**	**No. of terminal units *n***	**Hours on test** h	**Section volume *V*** l	$(2n/h)/V$	**Pressure drop found** kPa	**Pass/fail**	**Date of test**

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J4 (sheet .... of .... sheets)**

Complete installation: vacuum leakage tests

Hospital Scheme

This is to certify that a leakage test in accordance with **C.3.2** has been carried out on the piped vacuum system at a vacuum of .... kPa. The pressure increase after 1 h was .... kPa (maximum permitted 20 kPa).

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J5 (sheet .... of .... sheets)**

Complete installation: shut-off valves: leakage, closure, zoning and identification

Hospital Scheme

This is to certify that leakage, closure, zoning, and identification of the terminal units controlled by the shut-off valves have been tested according to **C.3.3** as follows.

Medical gas (name)	**Shut-off valve (number)**	**Test pressure** kPa	**Downstream pressure change** kPa	**Terminal units controlled (total no.)**	**Correct terminal unit labelling (yes/no)**

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J6 (sheet .... of .... sheets)**

Complete installation: cross-connection tests

Hospital Scheme

This is to certify that a cross-connection test in accordance with **C.3.4** has been successfully completed on the following systems.

Medical gas (name)	Date of test	Location

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J7 (sheet .... of .... sheets)**

Complete installation: test for obstruction and check of terminal units

Hospital Scheme

This is to certify that the following terminal units have been tested in accordance with **C.3.5** on the ..... medical gas pipeline.

Specified flow .... l/min. Specified pressure drop .... kPa.

Terminal unit no.	**Room no.**	**Correct flow**		**Correct pressure drop**		**Mechanical function and identification**		**Gas specificity**	
		Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J8 (sheet .... of .... sheets)**

Complete installation: check of NIST connectors

Hospital Scheme

This is to certify that the following NIST connectors have been checked in accordance with **C.3.5**.

Medical gas (name)	NIST connector number	Room number	Gas specificity	
			Yes	No

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J9 (sheet .... of .... sheets)**

Complete installation: system performance tests

Hospital Scheme

This is to certify that the ..... pipeline has been tested in accordance with **C.3.6** as follows.

System design flow .... l/min. Terminal unit test flow .... l/min.
Nominal distribution pressure .... kPa. Minimum distribution pressure allowed .... kPa.
Maximum distribution pressure allowed .... kPa.

Terminal unit no.	Room no.	Specification met		Terminal unit no.	Room no.	Specification met	
		Yes	No			Yes	No

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J10 (sheet .... of .... sheets)**

Complete installation: pressure relief valve tests

Hospital Scheme

This is to certify that the pressure relief valves fitted to the pipeline systems have been inspected/tested (delete as appropriate) in accordance with **C.3.7** as follows.

Inspection

Medical gas (name)	**Relief valve no.**	**Room no.**	**Full discharge capacity** l/min	**Full discharge pressure** *A* kPa	**Pipeline pressure** *B* kPa	*A*/*B* %

Testing

Medical gas (name)	**Relief valve no.**	**Room no.**	**Lift pressure** kPa	**Full discharge pressure** kPa	**Pipeline pressure** kPa	**Reseating pressure** kPa

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J11 (sheet .... of .... sheets)**

Complete installation: tests of sources of supply

Hospital Scheme

This is to certify that the following sources of supply have been tested in accordance with **C.3.8** and the attached checklists, and comply with the specification.

Source of supply	Date	Checklist number	Initials	
			Contractor's representative	Hospital representative
Manifold				
Manifold				
Manifold				
Manifold				
Manifold				
Cryogenic oxygen system				
Air compressor system				
Vacuum system				
Proportioning system				

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J12 (sheet .... of .... sheets)**

Complete installation: monitoring and alarm system tests

Hospital Scheme

This is to certify that the monitoring and alarm systems have been tested in accordance with **C.3.9** and comply with the specification.

Function tested	Oxygen	Nitrous oxide	Vacuum	Air for breathing	Air for tools
Specified alarm pressure					
Observed alarm pressure					
Return to normal					
Marking					
Visual characteristics					
Auditory characteristics					
All functions					
Standby power					

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J13 (sheet .... of .... sheets)**

Complete installation: purging with test gas

Hospital Scheme

This is to certify that all medical gas pipelines have been purged with the following test gases in accordance with **C.3.10**, and that all terminal units are free of particulate matter

Medical gas	Test gas	Terminal units tested	Visible particles (yes/no)
Oxygen			
Nitrous oxide			
Air for breathing			
Air for tools			

Contractor's representative

Status Signed
Date Name

Medical gas pipeline tests **Form J14 (sheet .... of .... sheets)**

Complete installation: test for particulate contamination of the pipeline

Hospital Scheme

This is to certify that the following pipelines have been tested for particulate contamination in accordance with **C.3.11**.

Medical gas	Terminal units tested	Visible particles (yes/no)
Oxygen		
Nitrous oxide		
Air for breathing		
Air for tools		

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Medical gas pipeline tests **Form J15 (sheet .... of .... sheets)**

Complete installation: filling with specific gas

Hospital Scheme

This is to certify that the following medical gas pipelines have been filled with the specific gas in accordance with **C.3.12**.

Medical gas (name)	Filling	Flow from all terminal units observed

Contractor's representative

Status Signed
Date Name

Medical gas pipeline tests **Form J16 (sheet .... of .... sheets)**

Not used.

Medical gas pipeline tests **Form J17 (sheet .... of .... sheets)**

Complete installation: gas identity

Hospital Scheme

This is to certify that the identity of the gas at all terminal units has been tested in accordance with **C.3.14** as follows.

Test using an oxygen analyser

Medical gas	Nominal oxygen concentration % (*V/V*)	Measured oxygen concentration % (*V/V*)
Oxygen	100	
Air	21	
Nitrous oxide/oxygen	50	
Nitrous oxide	0	

Test using differential pressure

Medical gas	Pressure used	Pressure recorded
Nitrous oxide		
Carbon dioxide		
Nitrogen for driving surgical tools		

Test using differential pressure

Medical gas	Pressure used	Pressure recorded
Air for breathing		
Air for driving surgical tools		

Contractor's representative

Status Signed
Date Name

Hospital representative

Status Signed
Date Name

Authorized person

Status Signed
Date Name

Annex K (informative)
Bibliography

prEN 737-6:1996, *Medical gas pipeline systems — Part 6: Dimensions of probes for terminal units for compressed medical gases and vacuum.*
prEN 1268-1, *Safety devices for the protection against excessive pressure — Part 1: Safety valves.*
prEN 1268-5, *Safety devices for the protection against excessive pressure — Part 5: Controlled safety pressure relief systems.*
prEN 13159, *Compatibility of medical equipment with oxygen.*
prEN 13348:1998, *Copper and copper alloys — Seamless round copper tubes for medical gases.*
ISO/TR 7470, *Valve outlets for gas cylinders — List of provisions which are either standardized or in use.*
ISO 10083, *Oxygen concentrators for use with medical gas pipeline systems.*
HTM 2022, *UK Department of Health: NHS Estates Health Technical Memorandum Medical Gas Pipeline Systems — Design, Installation, Validation and Verification.*
NF S 90-155, *Réseaux de distribution de gaz médicaux non inflammables.*

Annex L (informative)
Rationale

4.2 Evidence will be provided to e.g. a notified body during CE conformity assessment and upon request to the competent authority. Attention is drawn to EN 1441 on risk analysis and to the standards under development by ISO/TC 210 on risk evaluation and risk control.

4.3.1, 4.3.2, 4.3.3, 4.3.4, 4.3.5, 4.3.6, 4.3.8, 5.1.12, 5.2.7, 5.4.2.11, 12.4.7 Evidence will be provided e.g. to a notified body during CE conformity assessment and to the competent authority upon request.

5.1.6, 5.1.7 Evidence will be provided e.g. to a notified body during CE conformity assessment and to the competent authority upon request. Bursting discs are not permitted as a means of pressure relief since their operation can lead to complete loss of pressure in a pipeline.

5.2.8 Ignition of polymer-lined high presure flexible hoses is known to have occurred in several countries e.g. as a result of adiabatic compression. Decomposition of certain polymers can occur at temperatures which can be produced by adiabatic compression. The products of decomposition and combustion of some polymers are known to be extremely toxic. Until a standard has been published which addresses these known hazards the use of polymer-lined flexible hoses is therefore not permitted.

12.1.3 If the pressure measuring device is to be used to measure a pressure change of 0,1 kPa, then the resolution of the pressure measuring device should not exceed 0,01 kPa.

Annex ZA (informative)
Clauses of this European Standard addressing Essential Requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU Directive 93/42/EEC.

> WARNING Other requirements and other EU Directive may be applicable to the product(s) falling within the scope of this standard.

The following clauses of this standard are likely to support requirements of Directive 93/42/EEC.

Compliance with these clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and EU Directives

Clause/subclause of this European Standard	Corresponding Essential Requirement of Directive 93/42/EEC	Comments
4	1, 2, 7.1, 7.3	
4.3.2	9.2, 9.3, 12.7.1	
4.3.3	9.3	
4.3.4	9.3	
4.3.6	7.6	
5	1, 2	
5.1.4	3	
5.1.6	9.2	
5.1.7	9.2	
5.2.4	7.6	
5.2.8	7.1	
5.4.2.8	7.6	
5.4.2.10	12.7.2	
5.4.2.11	7.1	
5.6.1	8.1	
5.6.8	8.1	
5.6.9	12.7.2	
6	1, 2, 12.3, 12.8.1, 12.8.2, 12.9	
7	1, 2	
7.1	9.3, 12.7.1	
8	1, 2	
9	9.1, 12.7.4, 13.6c)	
9.3	9.2, 12.5, 12.6	
11	1	
11.1.3	12.6	
12	1, 2	
12.3.1	9.3, 12.7.1, 9.2	
12.4.1	7.5	
12.4.11	7.2	
13	4, 13.1, 13.3j), 13.3k), 13.6d)	
Annex B	1, 2	
Annex F	1, 2	
Annex G	13.3j), 13.3k)	

BS EN 737-3:2000

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