INTERNATIONAL STANDARD

ISO 7396

First edition
1987-06-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
ORGANISATION INTERNATIONALE DE NORMALISATION
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Non-flammable medical gas pipeline systems

Réseaux de distribution de gaz médicaux non inflammables

Reference number
ISO 7396 : 1987 (E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7396 was prepared by Technical Committee ISO/TC 121, *Anaesthetic and respiratory equipment.*

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Printed in Switzerland

Contents

Annexes

Non-flammable medical gas pipeline systems

0 Introduction

In medical gas pipeline systems it is vital that high safety standards are maintained and that there is no risk of failure of supply or plant without adequate warning. To ensure this, particular consideration has been given to the following:

a) design of equipment to ensure non-interchangeability between services;

b) use of correct materials, and cleanliness of materials;

c) correct installation;

d) provision of reserve supplies of gas, and reserve plant;

e) warning systems;

f) testing and commissioning to ensure that pipelines are not cross-connected;

g) identification of pipelines.

NOTE — Components of the non-flammable medical gas system (hereinafter referred to as the "pipeline system") should be installed by a manufacturer(s) or under the supervision of a manufacturer(s) or person(s) familiar with the correct practices for construction, installation and use.

In many countries, there are national standards, regulations or legal requirements dealing with one or more matters referred to in this International Standard, for example building, fire and electrical regulations. These often vary in their details and it is recognized that these may have to take precedence over the requirements of this International Standard.

It is impossible to overstress the importance of maintenance in ensuring that a medical gas pipeline system continues to perform to the requirements of this International Standard. For this reason, the installer of a system is required to provide drawings and maintenance schedules to the owner or user of the system (see 11.5) and it is the responsibility of the owner or user to ensure that proper maintenance is carried out under an effective method of control. Annex D gives recommendations for the organization of a maintenance operation. Annex F gives recommendations for emergency procedures.

When the installer retains ownership of parts of the gas supply system, he is responsible for their maintenance.

Medical gases, particularly oxygen, require knowledge of their characteristics and hazards, and the precautions to take regarding their care, handling, distribution and control. Reference should be made to national codes and regulations and/or an appropriate authority for such information.

The scope of this International Standard does not include the provision for gas-specific connectors for cryogenic storage vessels and transport vehicles, nor for the inlet/outlet connectors or portable liquid, cryogenic or gas cylinders. Such gas-specific connectors, however, are essential to ensure that only the correct gas can be used for the gas supply to a patient. The user of this International Standard should ensure that the supplier of the gas is using such gas-specific connectors.

NOTE — Terminal units have a range of non-interchangeable screwed and quick-connect connectors which are specified in ISO 5359. These are intended for use, for example, as inlet connectors to a continuous flow anaesthetic machine and other medical devices (see also ISO 407 and ISO 5145).

1 Scope and field of application

1.1 This International Standard specifies minimum requirements for the installation, construction, function, documentation and testing of non-flammable medical gas pipeline systems to ensure patient safety by delivery of the correct gas from the pipeline system. It includes requirements for the source of supply, distribution system, terminal units, warning systems, and for non-interchangeability between key components and service outlets.

1.2 It applies only to pipeline systems for the following non-flammable medical gases:

a) oxygen;

b) nitrous oxide;

c) medical air;

d) nitrogen;

e) helium[1];

f) carbon dioxide;

g) specified mixtures of the gases listed in a) to f);

h) medical vacuum.

1) Special consideration should be given to material and installation for helium services.

1.3 It applies to pipeline systems used at pressures required for patient care, including therapeutic, diagnostic and prophylactic applications and surgical tool applications. Pipeline systems used for non-clinical purposes are excluded. A medical air pipeline, supplied from an air compressor system only, may be extended to applications not directly related to patient care and certain precautions are given in annex G, for applications such as

a) the operation of ceiling columns in theatres;

b) anaesthetic waste gas systems;

c) sterilizer departments;

d) breathing air for surgical personnel;

e) pneumatic control of air conditioning;

f) testing of medical equipment.

Extensions are not permitted for applications such as

a) general workshop use;

b) motor repair workshops;

c) spray painting;

d) tyre inflation;

e) those which may impose unforeseen demands, which could prejudice the availability and/or quality of medical air for normal patient care purposes;

f) reservoirs for pressurization of hydraulic fluids.

2 References

ISO 32, *Gas cylinders for medical use — Marking for identification of content.*

ISO 65, *Carbon steel tubes suitable for screwing in accordance with ISO 7/1.*

ISO 274, *Copper tubes of circular section — Dimensions.*

ISO 407, *Small medical gas cylinders — Yoke-type valve connections.*

ISO 5145, *Cylinder valve outlets for gases and gas mixtures — Selection and dimensioning.* [1].

ISO 5359, *Low-pressure flexible connecting assemblies (hose assemblies) for use with medical gas systems.* [1]

IEC Publication 364, *Electrical installations of buildings.*

IEC Publication 601-1, *Medical electrical equipment — Part 1: General requirements.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 (non-flammable medical gas) pipeline system: The complete system which comprises a central supply system with control equipment, a pipeline distribution system and terminal units at the points where non-flammable medical gases may be delivered (see figure 1).

3.2 central supply system: A source of medical gas comprising one or more of the following items of plant:

a) a system of gas cylinders (see figures 6 and 12);

b) cryogenic or non-cryogenic liquid supply (see figures 7, 8 and 12);

c) air compressors (see figures 9 and 12);

d) proportioning equipment (see figures 11 and 12);

e) medical oxygen concentrators;

f) vacuum pumps (see figure 10);

3.3 primary supply: That portion of the central supply system which supplies the pipeline distribution system.

3.4 secondary supply: That portion of the central supply system which automatically supplies the pipeline distribution system when the primary supply becomes exhausted or fails and then becomes the primary supply.

3.5 reserve supply: That portion of the central supply system, activated manually or automatically, which supplies the pipeline distribution system in the event of failure of the primary and secondary supplies.

3.6 cryogenic liquid system: Liquid oxygen or liquid nitrogen central supply system which consists of a primary supply with either a secondary supply, a reserve supply or both (see figures 7, 8 and 12).

NOTE — Liquefied nitrous oxide and carbon dioxide are not cryogenic.

3.7 non-cryogenic liquid system: Supply system of nitrous oxide and carbon dioxide with reserve supply.

3.8 source of supply: Central supply system with associated control equipment and that portion of the pipeline up to and including the main pipeline shut-off valve.

3.9 air compressor system: System which comprises two or more air compressors designed to provide clean, dry, oil-free air to a pipeline distribution system at a constant pressure through its control equipment (see figures 9 and 12) which should include a reserve supply.

3.10 vacuum system: A system which comprises two or more vacuum pumps designed to provide a vacuum (see figure 10).

1) At present at the stage of draft.

3.11 proportioning equipment: Central supply system in which gases can be mixed in specified ratios (see figures 11 and 12).

3.12 medical oxygen concentrator (for example a pressure swing adsorber): 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.

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

3.14 pipeline distribution system: That part of a pipeline system linking the source of supply to the terminal units, including any necessary branch isolation valves and any additional line pressure regulators required (see figures 1 and 12).

3.15 terminal unit: An outlet assembly (inlet for vacuum) in a piped medical gas distribution system at which the user makes connections and disconnections (see figure 4).

3.16 terminal unit check valve: A valve which remains closed until opened by insertion of an appropriate probe and which then permits flow in both directions.

3.17 terminal unit maintenance valve: A valve within the terminal unit assembly which permits maintenance of the terminal unit without shutting down the pipeline system to other terminal units.

3.18 terminal unit base block: That part of a terminal unit which is permanently attached to the pipeline distribution system, or attached to a connecting assembly.

3.19 gas-specific connection point (socket assembly): That part of a terminal unit which is the receptor for a non-interchangeable gas-specific connecting assembly and which is attached to the base block by the appropriate non-interchangeable gas-specific device.

3.20 shut-off valve; isolating valve: A manual or automatic valve which prevents flow in both directions when closed.

3.21 non-return valve: A valve which permits flow in one direction only.

3.22 low-pressure flexible connecting assembly: A hose, tube or pipe with permanently attached gas-specific connectors, which is normally designed to conduct a medical gas at its nominal operating pressure (see ISO 5359).

3.23 gas-specific connectors: Connectors which are either NIST (non-interchangeable screw-threaded) or DISS (diameter-indexed safety system), or non-interchangeable quick connectors.

3.24 pressure-safety valve: A valve to limit the pipeline pressure downstream of line pressure regulators.

3.25 pressure-relief valve: A valve to limit pressure downstream of any operating pressure regulator.

3.26 operating alarm: Visual, or visual and auditory, alarm to indicate the necessity for technical staff to adjust the supply or to correct a malfunction.

3.27 emergency alarm: Visual and auditory alarm to indicate to technical and medical staff that the supply is outside normal operating limits.

3.28 nominal operating pressure: The normal pressure at which pipeline distribution systems are designed to operate.

3.29 system design flow capacity: Flow capacity calculated from the maximum flow requirements of the health care facility corrected by operational diversity factor.

4 Materials

NOTE — Special consideration should be given to materials and installation for helium services.

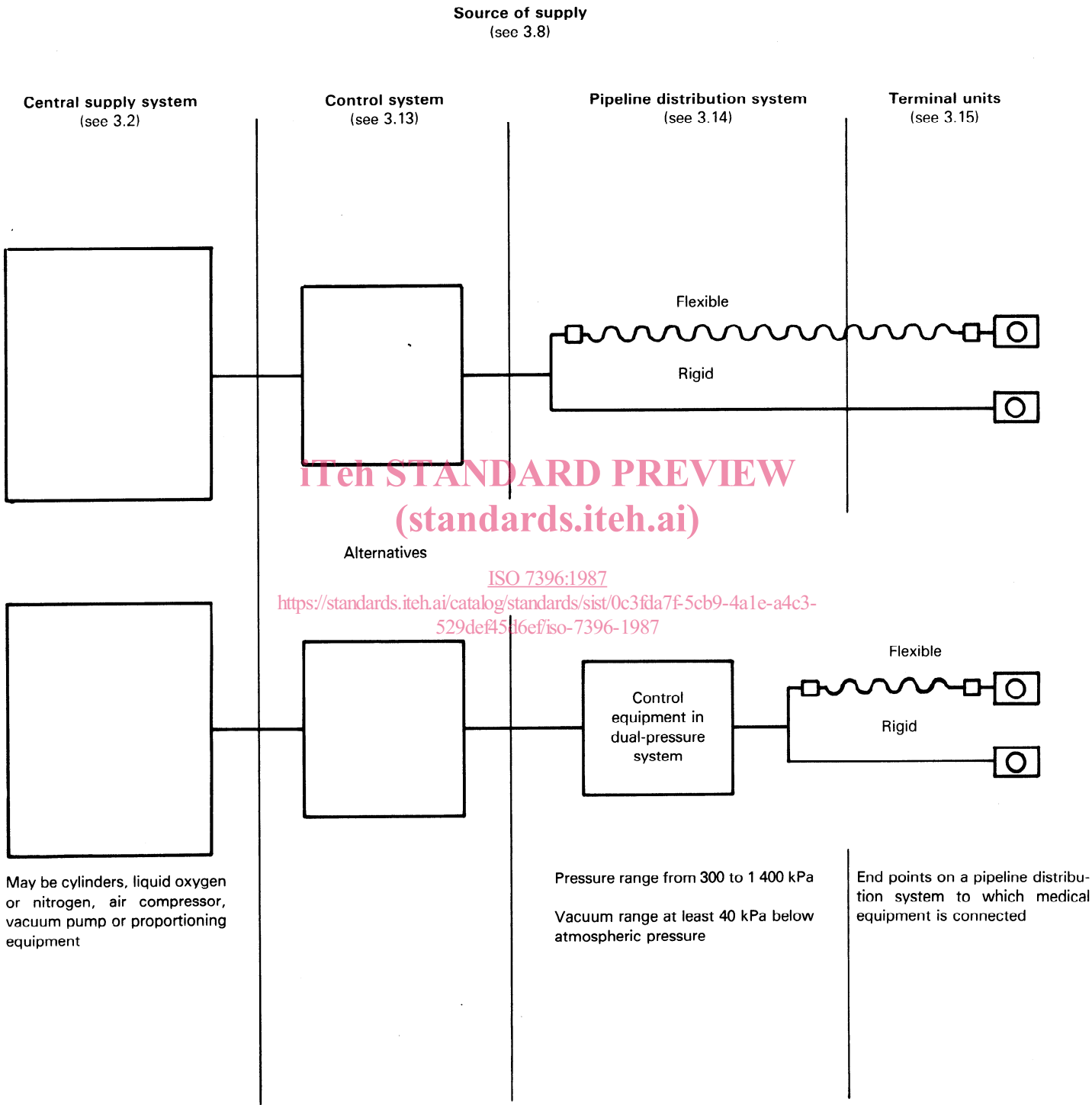
4.1 Compatibility with oxygen

4.1.1 Except for vacuum systems, the components of a pipeline system for medical gases shall be compatible with oxygen under all conditions and shall be clean and free from oil, grease and particulate matter.

NOTE — The anti-corrosion properties of all components against oxygen, moisture and surrounding materials should be considered. Compatibility 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, materials which can be ignited in air require lower ignition energies in oxygen. Many such materials may be ignited by friction at a valve seat or stem packing by adiabatic compression produced when oxygen at high pressure is rapidly introduced into a system initially at low pressure.

No relaxation of the requirement in 4.1.1 is permitted for any gas because of the difficulties of segregation of materials in stores and particularly on hospital sites during installation.

For vacuum systems, a wider selection of materials is possible, for example plastics, and in this case the provision for compatibility with oxygen need not apply.



NOTE — It is possible to have more than one pipeline pressure in the distribution system of a medical gas supply.

Figure 1 — Typical general layout of a non-flammable medical gas pipeline system

4.1.2 Components as specified in 4.1.1 shall include, but not be limited to, containers, pipes, valve seats, lubricants, fittings and gaskets.

4.1.3 Pipelines shall be made of materials given in annex A or appropriate equivalents.

4.2 Cleaning

All pipes, valves and fittings shall be cleaned and degreased before installation.

NOTE — These items should be supplied clean and degreased.

All precautions shall then be taken to maintain cleanliness during transportation, storage and installation.

5 Source of supply

5.1 General requirements

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

5.1.2 The source of supply may consist of one or more of the following:

a) gas in manifolded portable cylinders;

b) gas in manifolded cylinders on a trailer or pallet;

c) cryogenic liquid in portable cylinders (sometimes manifolded);

d) cryogenic liquid in manifolded cylinders on a trailer;

e) cryogenic liquid in a stationary vessel(s);

f) liquefied gas in a vessel;

g) a medical air-compressing system;

h) a medical vacuum-pumping system;

i) a proportioning system;

j) a medical oxygen concentrator.

5.1.3 The following provision for failure of supply shall be made.

In a cryogenic liquid oxygen system, an inlet to the system for connecting a temporary source for emergency/maintenance situations shall be incorporated in a convenient location. The inlet shall be physically protected to prevent tampering and unauthorized access. It shall have a gas-specific inlet. This connection shall be suitably controlled with the necessary valves to allow standby or emergency supply of medical gas and isolation of the normal source of supply. The emergency source shall incorporate a pressure regulator and safety-relief device which may or may not be a permanent part of the inlet to the system.

NOTES

1 If the reserve supply is housed separately and the normal source of supply isolated, this inlet may not be necessary.

2 For all other systems except vacuum, an alternative emergency inlet point may be provided. Any such connector should be gas-specific.

3 For special care locations (such as an anaesthetizing area, a recovery area, an intensive care unit or a coronary care unit) where patients are dependent on medical gas and/or medical vacuum, an alternative local source should be available, for example a cylinder or cylinder combination with a pressure regulator, or in the case of medical vacuum, a portable suction unit.

4 When a single cylinder with pressure regulator is used, the cylinder valve and regulator inlet should be of the same type gas-specific connector. The regulator outlet should be gas-specific as required for low-pressure flexible connecting assemblies.

5.1.4 Manifolds shall be of a construction and of a design and materials suitable for the service pressures involved. Manifold cylinder connections broken during cylinder changing operations shall be gas-specific.

5.1.5 All bulk liquid vessel connections shall be gas-specific and non-interchangeable between services. Adaptors are prohibited on the delivery vehicles. The vessel should be fitted with an outlet where a sample can be taken for analysis.

NOTE — A report on the concentration of gas should be provided by the supplier with each shipment of cryogenic liquid medical gases.

5.1.6 All pipeline regulators within a system shall together be capable of controlling pipeline pressure at levels which meet the requirements specified in table 1.

NOTE — Heating of pressure-control regulators or associated pipework may be necessary under high flow conditions to reduce frosting and condensation within the control equipment. Precautions to avoid overheating should be taken.

5.1.7 Control systems shall be designed so that regulators, relief valves, pressure alarm sensors and change-over valves can be maintained without interrupting the gas supply to the pipeline distribution system.

5.1.8 A pressure-relief valve shall be installed downstream of each operating pressure regulator and upstream of the line pressure regulator(s). This relief valve shall be set to lift at a pressure 30 % to 40 % above the nominal operating pressure and shall reach its maximum designed flow capacity (i.e. maximum relief valve full discharge) at a pressure not more than 50 % above its maximum lifting pressure (see figure 2).

5.1.9 A pressure-safety valve shall be installed downstream of line pressure regulator(s) but before the emergency alarm switch and main shut-off valve. This safety valve shall open at a pressure 30 % to 40 % above the nominal line operating pressure and shall reach its maximum designed flow capacity (i.e. maximum safety valve full discharge) at a pressure not

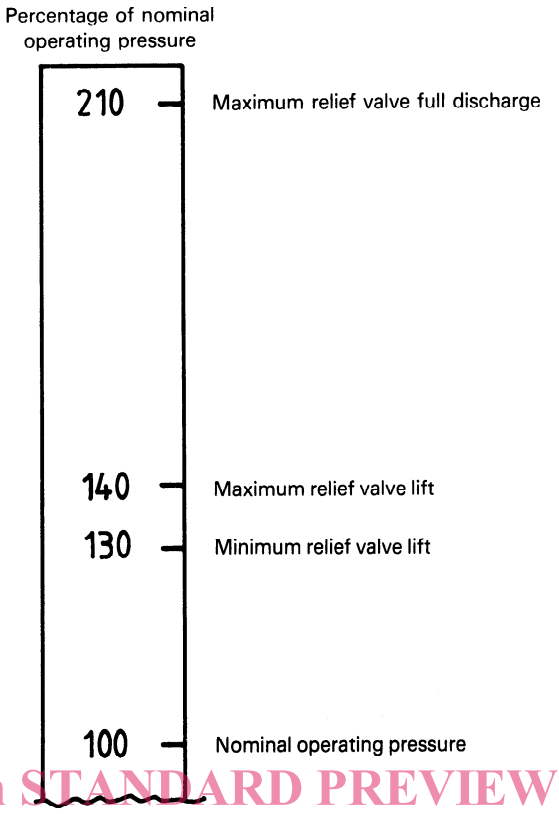


Figure 2 — Control settings of a pressure-relief valve

more than 60 % above the nominal operating pressure (see figure 3). For a nitrous oxide system the safety valve shall open at a pressure 25 % to 35 % above the nominal line operating pressure and shall reach its maximum designed flow capacity (i.e. maximum safety valve full discharge) at a pressure not more than 55 % above the nominal operating pressure.

NOTE — When a high percentage of nitrous oxide is being used during anaesthesia, a rise of the nitrous oxide pressure above 20 % of the operating pressure would further raise the percentage of nitrous oxide in the gas mixture which could be hazardous to the patient.

5.1.10 Safety/relief valves for air may be vented to the outside of the building. Those for all other gases in single pressure systems shall be vented to the outside of the building.

NOTE — The lower pressure section of a multi-pressure distributing system should be vented to the outside of the building, where practicable.

No shut-off valve or flow-restricting device shall interfere with the operating of these safety/relief valves.

NOTE — To maximize safety and ease of maintenance, it is recommended that a three-way duplex safety/relief valve be fitted.

5.2 Supply system with cylinders

NOTE — Typical supply systems with cylinders are shown in figures 6 and 7.

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

NOTES

1 A supply system with cylinders may include non-cryogenic cylinders, i.e. as used for the supply of nitrous oxide and carbon dioxide. The requirements of 5.2.1, 5.2.2, 5.2.3 and 5.2.4 apply to such cylinders.

2 When an exhausted bank of cylinders is replaced, the change-over system and alarm system may be reset either manually or automatically.

5.2.2 A non-return valve or manually-operated isolation valve shall be installed at the manifold end of each connecting pipe between each cylinder and the manifold header.

NOTE — The purpose of this valve is to prevent the loss of gas from the cylinders connected to the manifold if the safety/relief device on an individual cylinder should function or a cylinder flexible connection should fail.

5.2.3 A cylinder supply system shall comprise

a) a primary gaseous or cryogenic liquid supply which supplies the pipeline;

b) a secondary gaseous or cryogenic liquid supply which shall operate automatically to supply the pipeline as the primary supply becomes exhausted.

It may also have a permanently connected reserve supply which may be operated manually or automatically in the event of both the primary and the secondary supplies being unable to supply the pipeline.

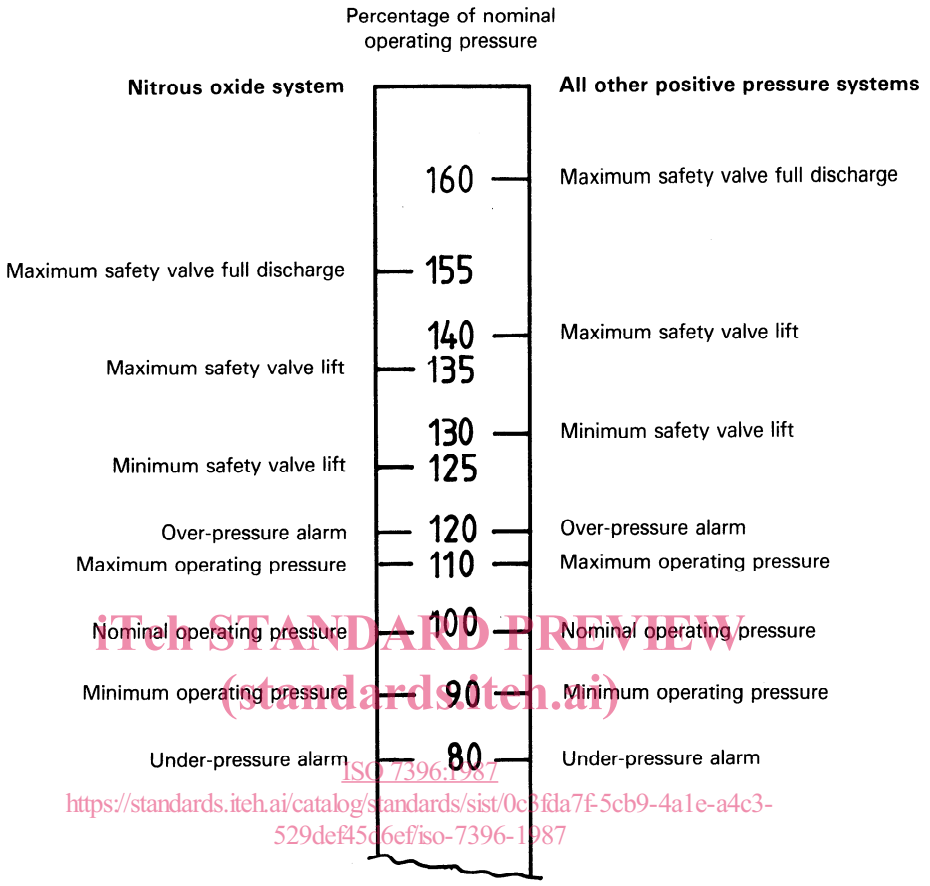


Figure 3 — Pressure-safety valve and alarm pressure settings

5.2.4 There shall be a supply of gas cylinders in reserve either attached to the manifold, or held in a hospital storage area that is readily available. The volumetric capacity of the reserve supply shall be specified, taking into account the average demand and availability of the gas concerned. (See annex F.)

5.2.5 If a cryogenic liquid cylinder supply is installed, it shall be in accordance with the principles indicated in figure 7.

5.2.6 Cryogenic liquid cylinder supply systems shall be provided with pressure-relief devices on the manifold.

5.3 Supply systems with stationary cryogenic vessels

NOTE — Typical supply systems with stationary cryogenic vessels are shown in figure 8 and the location of stationary cryogenic vessels are specified in 5.8.

5.3.1 The cryogenic supply system shall consist of at least two sources of supply at all times. These may be either of the following:

a) two or more units alternately supplying the pipeline. When the primary supply is exhausted, the secondary supply automatically becomes the primary supply and the secondary supply is refilled after the change-over takes place;

b) one or more units continuously supplying the pipeline while another unit remains as the reserve supply and operates only in case of an emergency.

5.3.2 The reserve supply shall comprise either a liquid or a cylinder supply. The volumetric capacity of the reserve supply shall be specified, taking into account the average demand and availability of the gas concerned. (See annex F.)

NOTES

1 Any secondary and/or reserve supplies should have the designed flow capacity of the primary supply.

2 Where the gaseous or liquid supply is connected upstream of the line regulator, the line regulator and its associated relief valve should be duplexed with isolating valves.

3 In the case of a cylinder supply, additional cylinders should be held in an adjacent store.

5.4 Oxygen concentrator [pressure swing adsorber (PSA)]

If a PSA plant is used for the supply of oxygen-enriched air via a pipeline system, an automatically-operating reserve supply, a means of continuous analysis of oxygen concentration and alarms shall be provided.

NOTES

1 It is intended that an International Standard specifying requirements for PSA plants will be prepared and this clause will be superseded by that International Standard when it is published.

2 Until an International Standard for PSA plant has been developed, it is recommended that before a PSA system is installed, the medical and other responsible staff of the facility agree on the specific use(s) planned. This will ensure that proper guidance is given for the safe management of problems such as

a) gas-specific fittings;

b) labelling;

c) areas of distribution, e.g. operating rooms, intensive care units, emergency departments.

3 It is strongly recommended that the medical oxygen pipeline and its terminal units are not used for piping the output from oxygen concentrators.

4 Further information on PSA plants is given in annex H.

5.5 Medical air systems

NOTE — Typical medical air systems are shown in figures 6, 9, 11 and 12.

5.5.1 General

A central supply system for medical air shall be one of the following:

a) an air compressor system, as specified in 5.5.2;

b) an automatically-controlled proportioning system capable of producing a mixture of approximately 21 % (V/V) oxygen and approximately 79 % (V/V) nitrogen, from a central supply, as specified in 5.7;

c) a cylinder supply system for air, in accordance with 5.2;

d) a combination of the above.

5.5.2 Air compressor system

5.5.2.1 Each central source (see figure 9) shall comprise two or more units of such a capacity that the average calculated demand can be supplied with one unit out of service, and automatic controls arranged so that the units will supply the system in turn or simultaneously according to the demand on the system.

NOTE — The noise level arising from the operation of some compressors may be unacceptable in some situations and appropriate action should be taken.

5.5.2.2 Compressors may be of any type provided there is a means to reduce contaminants to approved levels (see 12.4.7).

5.5.2.3 Each unit shall have a control circuit arranged so that shutting off, or failure of, one unit will not affect the operation of other units.

5.5.2.4 All electrical wiring of the compressor system shall conform to the provisions of IEC Publication 364. Electrical systems shall be connected to both the normal and emergency power supplies. With more than two compressors, not all compressors need to be connected to the emergency power source, provided that an adequate supply of gas can be maintained during an emergency.

5.5.2.5 Receivers, if required, shall be capable of meeting the operational needs of the system.

NOTE — If only one receiver is provided, a by-pass system should be installed for inspection and maintenance.

5.5.2.6 Drains shall be installed on dryers, after-coolers, separators and receivers so that condensate can be drained.

5.5.2.7 The intake for the air system shall be located in a position where there is minimal contamination from internal combustion engine exhausts, vacuum systems, anaesthetic gas scavenging systems, ventilation system discharges and other contaminants. The air intake shall be provided with a filter for protection of components.

5.5.2.8 The air compressor system shall be equipped with at least two dryers, each having the full capacity of the calculated demand, and such filters as are necessary to produce air of the required quality (see 12.4.7), which shall be located upstream of the final pressure-control equipment.

5.5.2.9 Except for air for surgical tools, an air compressor system shall include a duplexed pressure-regulating system to maintain a constant pressure in the pipeline distribution system.

5.5.2.10 A flexible connection may be installed between the compressor and the pipeline to prevent transmission of vibration.

5.5.2.11 After-coolers may be necessary to ensure that the air entering the receiver shall be at or near ambient temperature.

5.5.2.12 If the compressed air supply is extended for non-clinical purposes, the precautions given in annex G shall be observed.

5.6 Medical vacuum systems

NOTE — Typical medical vacuum systems are shown in figure 10.

5.6.1 A central source shall comprise two or more units of such capacity that a minimum of 75 % of the system design flow capacity can be supplied with one unit out of service.

NOTE — The A-weighted sound pressure level arising from the operation of some vacuum pumps measured within the central supply room will exceed 85 dB. This level may be unacceptable in some situations and appropriate action should be taken.

5.6.2 Controls for a central source shall be provided to activate the additional unit(s) automatically should the operating unit(s) of the system be incapable of maintaining an adequate vacuum.

5.6.3 Each unit of the central source shall have a control circuit arranged so that shutting off, or failure of, one unit will not affect the operation of other units.

5.6.4 Electrical wiring of vacuum systems shall conform to the provisions of IEC Publication 364. The electrical source for the units shall be connected to both the normal and standby electrical power supplies. With more than two pumps, not all pumps need to be connected to the emergency power supply provided that an adequate vacuum can be maintained during an emergency.

5.6.5 Reservoirs, if required, shall be capable of meeting the operational requirements of the system.

5.6.6 If a reservoir is installed, a drain shall be fitted.

5.6.7 The exhaust from the vacuum pumps shall be piped to the outside with the end turned down and should be screened against insects. It shall be in a position where risk of contamination of occupied buildings is minimized.

5.6.8 A flexible connection may be installed between the vacuum pump and the pipeline to prevent the transmission of vibration.

5.6.9 Duplicate bacterial filters shall be fitted or other effective methods used to prevent the entry of bacteria into the equipment and to prevent their discharge to atmosphere.

NOTE — The use of a medical vacuum system as a means of evacuation of waste anaesthetic gases is not recommended unless careful consideration is given to the capacity of the system and to the hazard which may occur due to flammable or corrosive gases in the system.

5.7 Proportioning systems

NOTE — A typical proportioning system, for example for blending oxygen and nitrogen to produce air, is shown in figures 11 and 12.

5.7.1 The sources of medical gas for proportioning systems shall conform to the requirements of 5.2 and 5.3 and may be the same sources as those supplying the medical gas pipelines separately.

5.7.2 A central source of medical air employing a proportioning system shall include a reserve supply in the form of a cylinder manifold system which shall be permanently connected and which shall operate automatically.

5.7.3 A proportioning system for air shall operate automatically to produce air of the quality required by 5.5.1. The mixture shall be analysed continuously and the results shall be recorded. The system shall be arranged so that manual intervention is necessary to correct the composition of the air before reconnecting the mixer to the pipeline.

NOTE — Two sets of instruments should be provided, at least one of which is capable of independently and automatically shutting off the gas mixture from the pipeline.

5.7.4 A proportioning system shall be capable of supplying the mixture of the required composition over the entire range of specified flow.

5.7.5 A proportioning system shall include means for verifying the calibration of the analysers and the performance of the instruments by reference to a mixture of known composition.

5.7.6 If a proportioning system is required to supply medical gas mixtures other than air, it shall include all the safety features specified in 5.7.2 to 5.7.5.

5.8 Location of stationary cryogenic vessels

5.8.1 Stationary cryogenic liquid systems shall not be installed over subterranean structures such as underground bunkers, basement rooms, etc., and shall 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. (See figure 13.)

5.8.2 Except for vessels located as specified in 5.8.3, stationary cryogenic liquid oxygen and nitrogen vessels shall 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 shall be protected from the weather and the area fenced.

5.8.3 If a stationary cryogenic vessel is to be installed inside a building, then it shall be positioned in a room specially 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 as in 5.10 shall be incorporated in this building.

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

5.9 Location of manifolded cylinders

A supply system with manifolded cylinders may be installed in the open air, with the control panel protected from the weather or especially constructed for operation in the open air, and the area fenced. Alternatively, it may be installed inside a room specially constructed, suitably modified, well ventilated and fire-resistant.