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# SANS 10260-1:2021

Edition 2

# SOUTH AFRICAN NATIONAL STANDARD

## Industrial gas pipelines

## Part 1: Design, construction, installation, operation, examination and maintenance (excluding acetylene)

**WARNING**
**This document references other documents normatively.**

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**Table of changes**

| Change No. | Date | Scope |
|---|---|---|
| | | |

## Foreword

This South African standard was prepared by National Committee SABS/TC 1019, *Gas supply, handling and control (fuel and industrial gases) – Industrial gas*, in accordance with procedures of the South African Bureau of Standards, in compliance with annex 3 of the WTO/TBT agreement.

This document was approved for publication in January 2021.

This document supersedes SANS 10260-1:2004 (edition 1.2).

Reference is made in 3.40, 6.1.1, 6.2.2.3, 7.6.5, 8.15.2.2, 8.15.3.2, 8.18.1 and 9.3.1.1 to the "relevant national legislation". In South Africa this means the Pressure Equipment Regulations of the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Reference is made in 9.6.1, 9.7.1, 9.6.2, E.5.5 and F.5.4 to the "relevant national legislation". In South Africa this means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Reference is made in E.5.13 and F.5.12 to the "relevant national body". In South Africa this means the local fire service.

Reference is made in K.3.3 to the "relevant national legislation". In South Africa this means the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

SANS 10260 consists of the following parts under the general title *Industrial gas pipelines:*

*Part 1: Design, construction, installation, operation, examination and maintenance (excluding acetylene).*

*Part 3: Distribution of acetylene at consumer sites.*

Annexes A to J form an integral part of this document. Annex K is for information only.

**Compliance with this document cannot confer immunity from legal obligations.**

## Contents

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# Industrial gas pipelines

## Part 1:
Design, construction, installation, operation, examination and maintenance (excluding acetylene)

## 1 Scope

**1.1** This part of SANS 10260 gives the minimum safety requirements for the design, construction, installation, operation, examination and maintenance of industrial gas supply systems and associated distribution systems of up to 80 mm nominal bore.

NOTE The supply manifolds are supplied by gas cylinders filled to a settled pressure of up to 30 000 kPa (300 bar) gauge at 20 °C or by cryogenic containers of up to 1 000 L water capacity and maximum working pressures of up to 5 000 kPa (50 bar) gauge.

**1.2** Where cryogenic containers are used (or liquid take-off dip tube cylinders), this part of SANS 10260 relates to gaseous and not liquid distribution.

**1.3** This part of SANS 10260 also applies to gas distribution pipework systems supply from bulk storage vessels greater than 1 000 L.

NOTE The maximum distribution pipework pressures are limited to 5 000 kPa (50 bar) for the following gases and mixtures of these gases: argon, carbon dioxide, helium, hydrogen, nitrogen, methane/methane rich, oxygen and nitrous oxide.

**1.4** This part of SANS 10260 is intended for the use in the design and construct single-cylinder permanently piped systems.

**1.5** This part of SANS 10260 does not cover acetylene.

**1.6** This part of SANS 10260 does not cover special gases.

NOTE See BCGA CP 18 for guidance on special gases.

**1.7** This part of SANS 10260 does not cover medical gas systems. These are covered by SANS 7396-1.

## 2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the South African Bureau of Standards.

ASME B31.3, *Process piping.*

ASME BPVC-IX, *Welding, brazing, and fusing qualifications – Section IX: Qualification standard for welding, brazing, and fusing procedures; welders; brazers; and welding, brazing, and fusing operators.*

BS 1306, *Specifications for copper and copper alloy pressure piping systems.*

BS 2633, *Specification for Class 1 arc welding of ferritic steel pipework for carrying fluids.*

BS 2971, *Specification for Class II arc welding of carbon steel pipework for carrying fluids.*

BS 4872-1, *Specification for approval testing of welders when welding procedure approval is not required – Fusion welding of steel.*

BS 4872-2, *Specification for approval testing of welders when welding procedure approval is not required – TIG or MIG welding of aluminium and its alloys.*

EIGA IGC 13, *Oxygen pipeline and piping systems.*

EN 13134, *Brazing – procedure approval.*

ISO 287, *Paper and board – Determination of moisture content of a lot – Oven-drying method.*

ISO 4126-1, *Safety devices for protection against excessive pressure – Part 1: Safety valves.*

ISO 11114-1, *Gas cylinders – Compatibility of cylinder and valve materials with gas contents – Part 1: Metallic materials.*

ISO 11114-2, *Gas cylinders – Compatibility of cylinder and valve materials with gas contents – Part 2: Non-metallic materials.*

ISO 13585, *Brazing – Qualification test of brazers and brazing operators.*

SANS 347, *Categorization and conformity assessment criteria for all pressure equipment.*

SANS 1062, *Pressure and vacuum gauges.*

SANS 1109-1/ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances and designation.*

SANS 1123, *Pipe flanges.*

SANS 1186-1, *Symbolic safety signs – Part 1: Standard signs and general requirements.*

SANS 1700 (all parts), *Fasteners.*

SANS 1306-1/ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation.*

SANS 10108, *The classification of hazardous locations and the selection of equipment for use in such locations.*

SANS 10140-3, *Identification colour markings – Part 3: Contents of pipelines.*

SANS 10142-1, *The wiring of premises – Part 1: Low voltage installations.*

SANS 10400-T, *The application of the National Building Regulations – Part T: Fire protection.*

SANS 14113/ISO 14113, *Gas welding equipment – Rubber and plastic hoses assembled for compressed or liquefied gases up to a maximum design pressure of 450 bar.*

## 3 Terms and definitions

For the purposes of this part of SANS 10260, the following definitions apply.

**3.1**
**acceptable**
acceptable to the authority administering this standard, or to the parties concluding the purchase contract, as relevant

**3.2**
**adiabatic compression**
compression in which no heat is added or removed from the gas during compression, the internal energy of the gas is increased by an amount equivalent to the external work done on the gas

**3.3**
**alarm**
device which provides visual or audible warning of change in conditions such as pressure, flow or temperature

**3.4**
**appropriate**
minimum applicable or reasonable knowledge/practice/requirements to be applied

**3.5**
**authorised person**
person who is registered as competent within the scope of work for which an organization approved by the chief inspector that has registered that person

**3.6**
**auto change unit**
device used to ensure continuity of supply, from a dual supply system, by automatically changing from the service supply to the reserve supply

**3.7**
**bursting disc**
device that prevents over-pressure through the rupture of a disc

NOTE It is a non-re-closing relief device. Once activated, the entire system content is released.

**3.8**
**cryogenic**
relating to gases liquefied by deep refrigeration

**3.9**
**cryogenic container**
insulated container containing a cryogenic fluid

**3.10**
**cylinder bundle**
number of cylinders permanently manifolded to a common outlet and contained in a rigid protective framework for ease of handling by forklift truck or lifting equipment

**3.11**
**distribution**
pipework downstream of the cylinder regulator or manifold pressure regulator or cryogenic container

**3.12**
**filter**
element capable of restraining particles which may interfere with the operation of downstream equipment

**3.13**
**flashback arrestor**
device which arrests a flame front in a piping system and which is suitable for the most severe type of flame which may occur

**3.14**
**flexible hose assembly**
flexible connection between two components in the system

NOTE It may be manufactured from coiled metal tube (pigtail) or flexible material (hose).

**3.15**
**functional pressure test**
test carried out using a suitable test medium at system design pressure, or working pressure if this is lower, to check that the pressure equipment and its components function properly

NOTE It may include the actuation of moveable parts, such as the opening and closing of valves. This is normally done at the conclusion of pressure and leak testing, when protective devices have been refitted.

**3.16**
**header**
pipework for collecting gas at full pressure from one or more cylinders or gas containers

**3.17**
**heater**
device for raising the temperature of the gas to ensure complete vaporization of liquids or preventing a temperature drop

**3.18**
**installation**
combination of the supply system and distribution system

**3.19**
**isolating valve**
valve which gives positive shut-off

**3.20**
**leak test**
test performed at pressure not exceeding the system design pressure on pressure equipment which has satisfactorily passed the pressure test

NOTE 1 The purpose of this test is for the detection of leaks in the system.

NOTE 2 Testing is done by either checking the retained pressure over a specified time period, or by using an approved test solution to detect leaks.

**3.21**
**non-return valve**
self-actuating valve which prevents the passage of gas in the opposite direction to the normal flow

**3.22**
**normal temperature and pressure**
**NTP**
condition at a pressure of 101,3 kPa absolute at a temperature of 15 °C

**3.23**
**outlet point connection**
outlet assembly in a pipeline gas distribution system, at which the user makes connections and disconnections

**3.24**
**oxygen enrichment**
increase of oxygen content of an atmosphere to a stage where the oxygen content volume fraction is equal to, or exceeds, 23.5 %

**3.25**
**positive shut-off valve**
valve designed for and capable of closure to stop flow within a piping system

**3.26**
**pressure**

**3.26.1**
**high pressure**
pressure greater than 5 000 kPa (50 bar)

NOTE It is typically the source pressure.

**3.26.2**
**maximum working pressure**
maximum service pressure allowable up to which the system is allowed to operate

NOTE This may be lower or equivalent to the system design pressure.

**3.26.3**
**low pressure**
pressure equal to or less than 5 000 kPa (50 bar)

NOTE It is typically the distribution pressure i.e. after the pressure regulation.

**3.26.4**
**system design pressure**
design pressure of the system is always less than or equal to the lowest design pressure of any component in the system

**3.27**
**pressure drop**
loss of pressure through the system due to frictional forces and restrictions under flow conditions

**3.28**
**pressure gauge**
device that indicates pressure

**3.29**
**pressure test**
test of the system carried out in accordance with the relevant national legislation (see foreword)

**3.30**
**pressure regulator**
self-governing device for regulating a variable inlet pressure to the required outlet pressure

**3.31**
**pressure relief device**
device which automatically vents to prevent a dangerous build-up of pressure in a system when the pressure exceeds a predetermined value

**3.32**
**pressure relief valve**
valve that automatically opens to relieve pressure in a system when the pressure exceeds a predetermined value

**3.33**
**purging**
safe removal of air or any other gas that may be present in a system prior to the introduction of the service gas

**3.34**
**regulator mounting block**
mounting block fitted to the header pipe or distribution pipe, threaded to accept a regulator

**3.35**
**safety shut-off device**
device which automatically shuts off the gas supply when the set distribution pressure, flow or temperature is exceeded

**3.36**
**safe operating limits**
restriction of the system operating pressure and temperature to be within or at the system design pressure and the maximum/minimum design temperatures

**3.37**
**standard temperature and pressure**
**STP**
condition at a pressure of 101,3 kPa absolute at a temperature of 0 °C

**3.38**
**suitable**
appropriate for the service condition and to sound engineering practise

**3.39**
**supply manifold**
piping system connecting source pressure i.e. cylinders, cryogenic containers or cylinder bundles to the distribution system

**3.40**
**supply system**
central supply system with associated control equipment and that portion of the pipeline up to and including the main pipeline shut-off valve

**3.41**
**system design flow capacity**
flow capacity calculated from the maximum flow requirements of the entire system

**3.42**
**vaporizer**
device for converting liquid to gas by heat transfer

## 4 Supply systems

**4.1** The supply system is that part of an installation from the outlet of the gas cylinder, cylinder bundle or cryogenic storage container to the main pressure regulating equipment as shown schematically in figure 1. The schematic arrangement for supply systems in figure 1 shows all the components normally encountered for the range of gases covered by this part of SANS 10260. Only a few components will be required for most gases while others will be specific to individual gases. As shown in figure 1, the supply system is linked to the distribution system.

**4.2** The supply system shall be capable of withstanding maximum cylinder or cryogenic container pressure and the minimum temperature where applicable. The supply system is typically designed for high pressure.

**4.3** Gas containers of different pressures and products shall not be connected to the same supply manifold.

**4.4** Cryogenic containers of different pressure ratings and products shall never be connected to the same supply system.

**4.5** A cryogenic container shall not be connected to the same supply manifold as a compressed gas cylinder.

**4.6** The schematic arrangement in figure 1 is not intended for use as a specific installation. Table 1 identifies the various items and qualifies their status in respect of the various gases. Single cylinder installations are not considered to be a manifolded supply system. A suitable high-pressure gas specific regulator with a built-in pressure relief device may be fitted directly to the supply cylinder and connected directly to the pipeline.

**4.7** All cylinders shall be adequately secured when connected to a manifolded supply system or as a single cylinder installation.

**Table 1 — Gas supply system and component requirements**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gas supply** | **Supply container/Package valve(s)** | **Flexible hose assembly** | **Isolating valve** | **Non-return valve** | **Header** | **Pressure relief device** | **Purge valve** | **Header valve** | **Heater** | **Vaporizer** | **Filter** | **Safety shut-off device** | **Regulator mounting block** | **High-pressure gauge** | **Main regulator** | **Low-pressure gauge** | **Temperature control valve** | **Manifold non-return valve** | **Pressure relief Device** |
| Item (see figure 1) | B | C | D[1] | E[1] | F | G | H | I | J1 | J2 | K | L | M | N1 | N | N2 | O | P[1] | Q |
| **Oxygen** | E | E | R | R | E | N | O | E | N | N | R | O | O | R | R | E | N | R | R |
| **Hydrogen** | E | E | R | R | E | N | R | E | N | N | R | O | O | R | R | E | N | O | R |
| **Nitrogen/ Argon/ Helium** | E | E | O | R | E | N | O | E | N | N | R | O | O | R | R | E | N | O | R |
| **Vaporized cryogenic liquid** | E | E | R | R | E | E | O | E | O | E | R | N | O | O | R | E | R | N | E |
| **Carbon dioxide (Gas supply)** | E | E | R | R | E | O | O | E | O | O | R | O | O | R | R | E | N | O | R |
| **Vaporized liquid carbon dioxide** | E | E | R | R | E | E | O | E | O | E | R | O | O | R | R | E | O | N | E |
| **Methane** | E | E | R | R | E | N | R | E | N | N | R | O | O | R | R | E | O | O | R |
| **Mixed gases** | See mixed gases (appendix I) | | | | | | | | | | | | | | | | | | |
| NOTE 1 E = Essential R = Recommended O = Optional N = Not Applicable | | | | | | | | | | | | | | | | | | | |
| NOTE 2 Manifolds should incorporate one of the items D, E or P as a minimum. | | | | | | | | | | | | | | | | | | | |

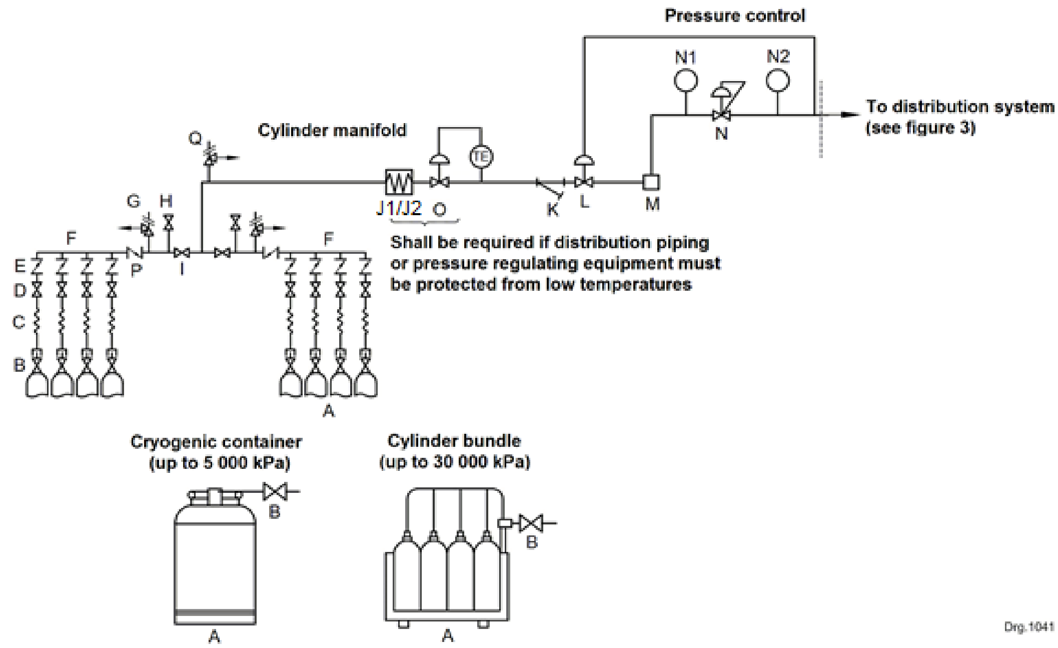



**Figure 1 — Supply systems**

NOTE 1 See table 1 for meaning of letter.

NOTE 2 Valves (I) may be replaced by a three-way valve/auto change unit.

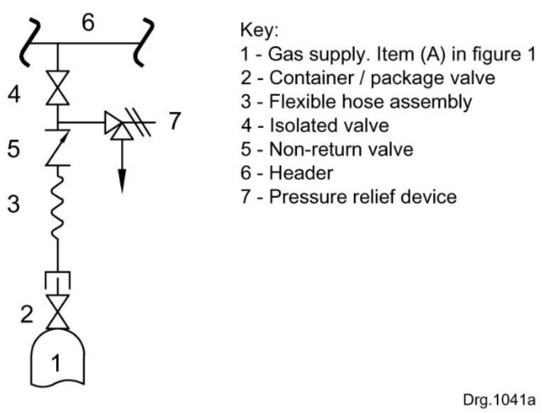



**Figure 2 — Protection requirements for liquid supply**

NOTE 1 Where the gas supply is only in the gaseous phase, (4) and (5) may be exchanged in position.

NOTE 2 Where the gas supply is possibly in the liquid phase, (4) and (5) may not be changed in position unless a safety relief device (7) is fitted as shown in figure 2, between (4) and (5).

NOTE 3 Where the gas supply is possibly in the liquid phase, item (3) should be protected by a non-isolatable relief device (7) between (2) and (4) as shown in figure 2 (see 7.6.6).

## 5 Distribution systems

**5.1** The distribution system is that part of an installation from the main pressure regulator equipment to the outlet point as shown in figure 3. The maximum distribution pipework pressures are limited to 5 000 kPa (50 bar) for the following gases and mixtures of these gases: argon, carbon dioxide, helium, hydrogen, nitrogen, methane/methane rich, oxygen and nitrous oxide.

**5.2** The distribution system pipework shall be operated at no more than its maximum working pressure and system design flow capacity. This system is typically designed for low pressure and the distribution system shall not be operated at pressures exceeding the maximum safe working pressure. The system shall also have suitable protection to prevent pressures exceeding system design pressure resulting from malfunction of the pressure regulator equipment or other abnormal circumstance.

**5.3** Any equipment downstream of the distribution system shall be suitable for the distribution system pressure or suitably protected.

**5.4** The schematic arrangement of a distribution system in figure 3 shows all the components which could normally be encountered for the range of gases covered by this part of SANS 10260. Only a few components will be required for most gases while others will be specific to individual gases. The schematic arrangement as shown in figure 3 is not intended for use as a specific installation.

**5.5** Table 2 identifies the various items and qualifies their status in respect of the various gases.

**Table 2 — Gas distribution system and component requirements**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gas distribution** | **Flexible hose** | **Pressure relief valve** | **Main isolation valve** | **Pressure gauge** | **Purge valve (s)** | **Section isolation valve** | **Section pressure gauge** | **Outlet isolation valve** | **Non-return valve** | **Flashback arrestor** | **Thermal cut-off device** | **Outlet connection point** |
| **Item** (see figure 3) | i | ii | iii | iv | v | vi | vii | viii | ix | x | xi | xii |
| **Oxygen** | O | E | E | O | O | E | R | E | E | O | O | E |
| **Hydrogen** | O | E | E | O | O | E | R | E | E | O | O | E |
| **Nitrogen/Argon/ Helium** | O | E | E | O | O | E | O | E | O | N | N | E |
| **Carbon dioxide** | O | E | E | O | O | E | O | E | O | N | N | E |
| **Methane** | O | E | E | O | O | E | R | E | E | O | O | E |
| **Mixed gases** | See mixed gases annex I | | | | | | | | | | | |

NOTE 1 E = Essential R = Recommended O = Optional N = Not Applicable

NOTE 2 Where the distribution system comprises of only one section, the section isolation valve (item vi) may be omitted.

NOTE 3 Outlet connection point (item xii) should be a gas-specific threaded connection. (See SANS 10019 and SANS 3821 for outlet specifications).

NOTE 4 See BCGA CP7 for the requirements for oxy fuel systems.

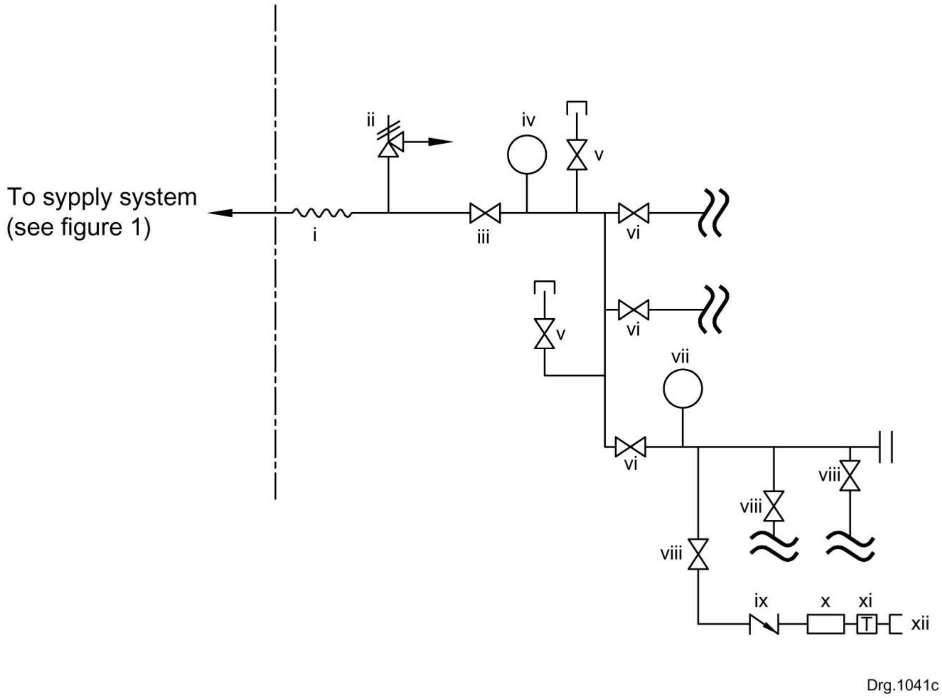



**Figure 3 — Distribution systems**

# 6 Design

## 6.1 General

**6.1.1** The system shall be designed in accordance with the relevant design standard(s) for example, ASME B31.3 and BS 1306 (for plastic piping see annex J) and shall comply with the requirements of the relevant national legislation (see foreword) and SANS 347.

**6.1.2** For flammable gases the installation shall be zoned in accordance with results of a zoning study, and only equipment suitable for that zone shall be used within it. SANS 10108 provides information on the zoning procedure.

**6.1.3** Materials, which may be exposed to the gas stream, shall be compatible with the particular gas and shall comply with ISO 11114-1 and ISO 11114-2. Recommended materials and cleanliness for specific gases are given in annexes A to I.

**6.1.4** Pipe systems shall be designed to avoid mechanical damage and minimize external stresses.

**6.1.5** Pipework in ducts should comply with the requirements in 8.9.2.

**6.1.6** Pipework liable to external corrosion shall be protected.

**6.1.7** Pipework shall be designed for ease of cleaning and purging particularly in oxygen service. Dead legs where foreign matter could accumulate shall not be used. The designer shall take into consideration the necessary purge, vent, isolation and indication points to allow for commissioning, decommissioning, maintenance, testing and allow for fault finding.

**6.1.8** Pipework should be as straight and direct as possible to avoid excessive pressure drop (and potential impingement points, for example, bends when conveying oxygen).

**6.1.9** Existing systems shall not be converted from one service to another unless:

a) the design is revalidated and reviewed (i.e. material compatibility and compliance with this part of SANS 10260); and

b) the equipment within the system has been reverified and is suitable for the rated pressures and service conditions.

**6.1.10** The equipment and pipes shall be cleaned in accordance with the relevant health and safety standard for the intended gas service.

## 6.2 Safety requirements

### 6.2.1 Safety distances

**6.2.1.1** The supply systems should, where practicable, be sited outdoors or in a manifold room, which are used solely for housing manifolds. Where the supply system and the manifold are separately located the appropriate safety distances shall apply to both locations. The safety distances given in table 3 shall be observed.

**6.2.1.2** The actual minimum safety distance to be observed shall be determined through a risk analysis taking into account the whole environment.

**Table 3 — Safety distances in metres**

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| **Location** | **Cryogenic oxygen ≤ 1 000 L water capacity** (see figure 4 and figure 5) | **Cryogenic inert ≤ 1 000 L water capacity** (see figure 4 and figure 5) | **Compressed oxygen** (see figure 6 and figure 7) | **Compressed inert** (see figure 6 and figure 7) | **Compressed flammable**[c] (see figure 8 and figure 9) |
| **Public places** | | | | | |
| Public assembly | 15 | 15 | 3 | 3 | 5 |
| Immobile patients | 15 | 15 | 10 | 10 | 10 |
| Public sidewalks | 5 | 3 | 3 | 3 | 5 |
| Public roads and rail lines | 5 | 3 | 3 | 3 | 5 |
| **Site** | | | | | |
| Property boundaries | 3 | 3 | 3 | 3 | 5 |
| Vehicle parking (non-authorised) | 3 | 3 | 3 | 3 | 5 |
| Congregations/Offices | 5 | 5 | 3 | 3 | 5 |
| Non fire-resistant buildings | 15 | 5 | 5 | 5 | 5 |
| Wall and building openings | 3 | 3 | 1 | 1 | 3 |
| Works/Construction sites | 5 | 2 | 2 | 2 | 3 |
| Low level drains, ducts, trenches, and basements | 5 | 5 | 1 | 2[a] | 1 |
| **Site equipment** | | | | | |
| Ventilation/Compressor intakes | 15 | 15 | 3 | 3 | 3 |
| Ignition sources/Naked flames | 5 | 2 | 2 | 2 | 5 |
| Electrical switchgear or Distribution boards | 3 | 2 | 2 | 2 | 3[b] |
| Spray booths | 15 | 3 | 3 | 3 | 3 |
| Fuel gas vents | 5 | 3 | 3 | 3 | 3 |
| Fuel pipes – Continuous | 3 | 3 | 3 | 3 | 3 |
| Fuel Pipes – Joints/Fittings | 5 | 3 | 3 | 3 | 3 |
| No entry during filling | 5 | 5 | N/A | N/A | N/A |
| Other process equipment/machines | 5 | 2 | 2 | 2 | 3 |
| **Storage** | | | | | |
| Combustible solids | 5 | 3 | 3 | 3 | 3 |
| Combustible/Flammable storage | 15 | 5 | 5 | 5 | 5 |
| Flammable liquids >5 000 L | 15 | 15 | 15 | 15 | 15 |
| Flammable liquids <5 000 L | 10 | 10 | 10 | 10 | 10 |
| LPG bulk storage | Refer to SANS 10087-3 | 5 | 5 | 5 | 5 |
| Gas cylinder storage – Flammable | 5 | 5 | 5 | 5 | 5 |
| Gas cylinder storage – Non-flammable | 5 | 3 | 3 | 3 | 3 |

**Table 3** *(concluded)*

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| **Location** | **Cryogenic oxygen ≤ 1 000 L water capacity** (see figure 4 and figure 5) | **Cryogenic inert ≤ 1 000 L water capacity** (see figure 4 and figure 5) | **Compressed oxygen** (see figure 6 and figure 7) | **Compressed inert** (see figure 6 and figure 7) | **Compressed flammable**[c] (see figure 8 and figure 9) |

NOTE 1 Distance (in metres) between gas storage vessels and hazards is based on risk posed by both the vessel on the activity and the activity on the vessel.

NOTE 2 Cryogenic: Maximum total water capacity is:
5 000 L for individual containers ≤ 1 000 L

[a] 2 m for $CO_2$, 1 m for other inert gases such as argon, nitrogen, helium, carbon dioxide, and mixtures of these gases.

[b] Refer to SANS 10108.

[c] Excluding LPG and Acetylene refer to SANS 10087.

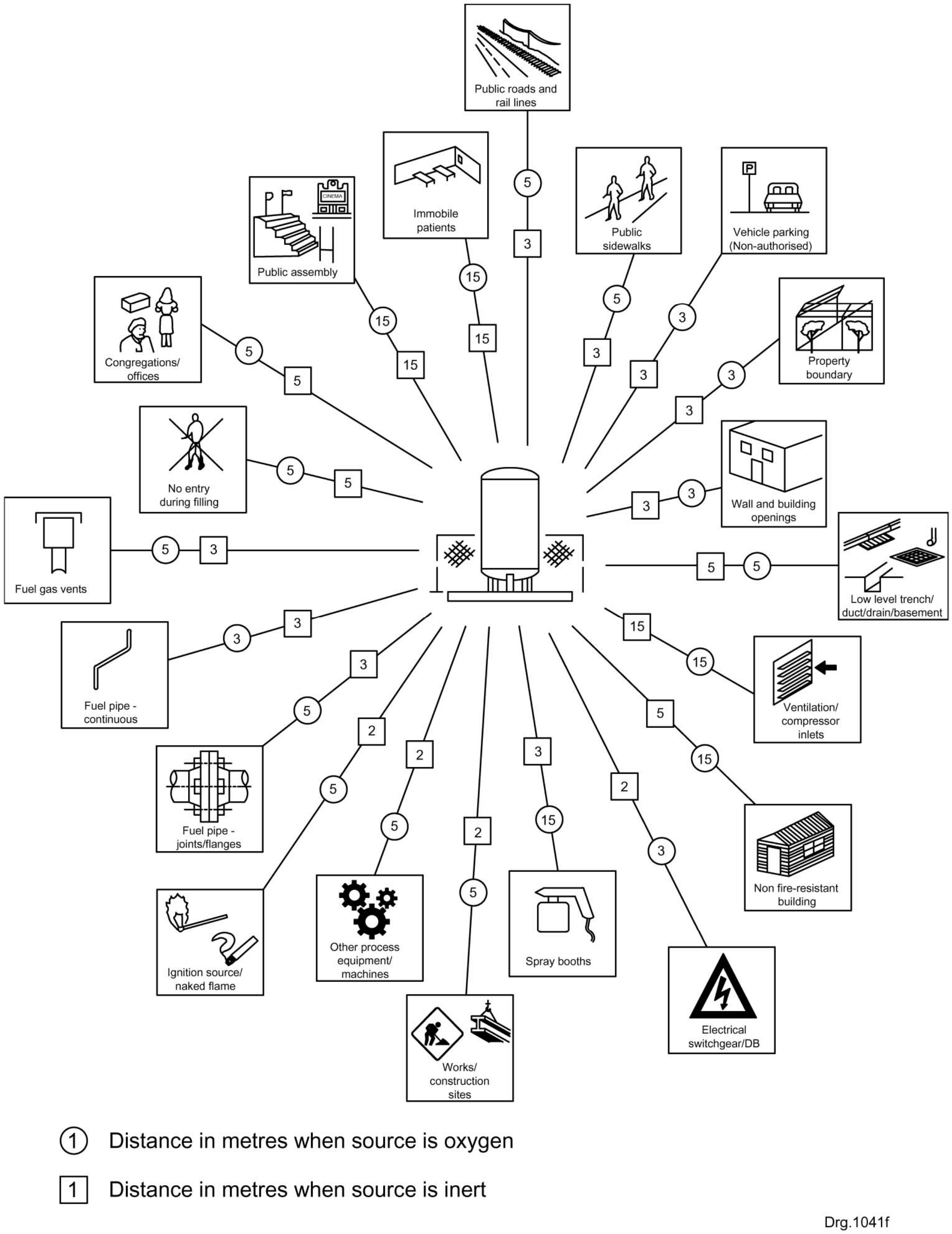
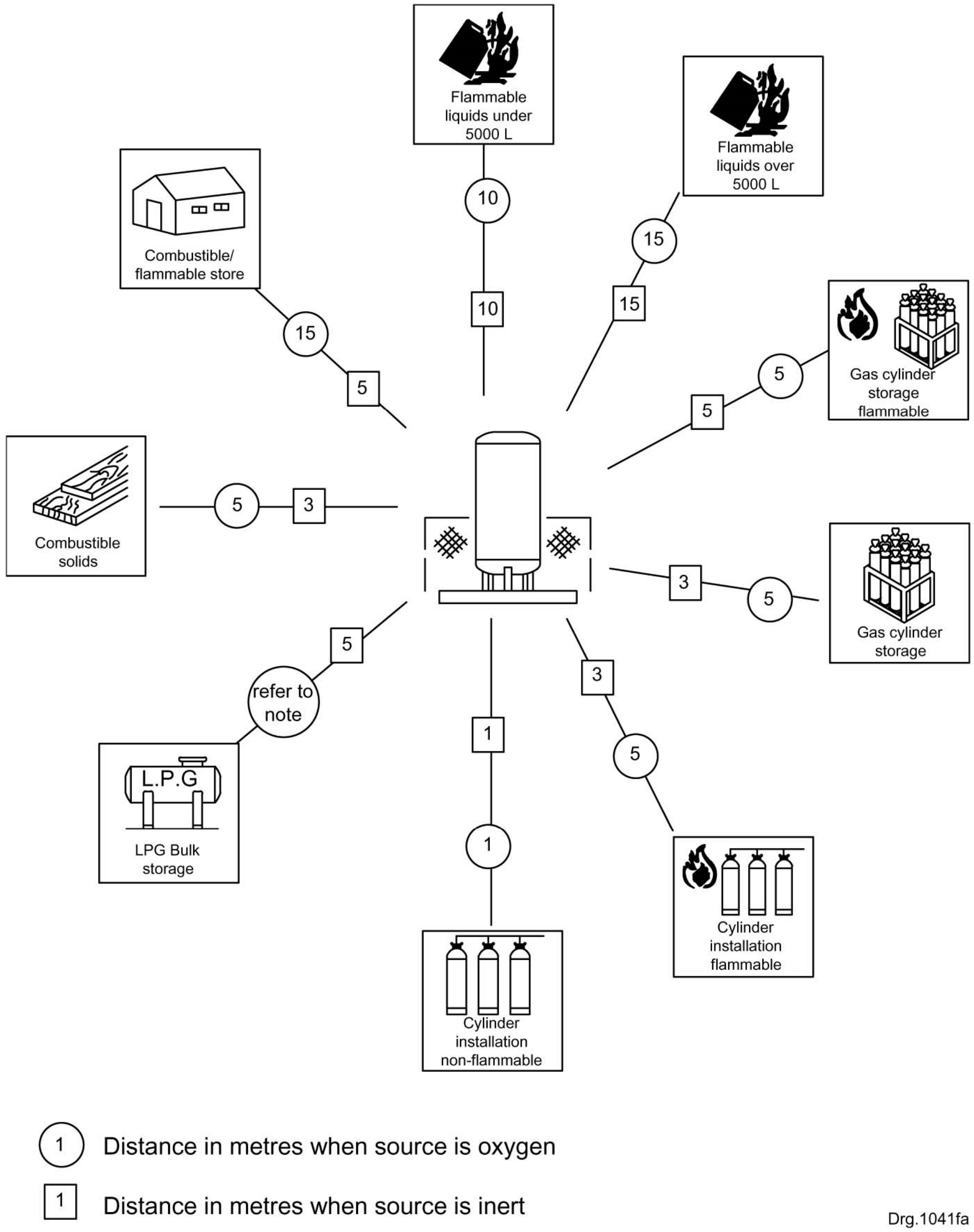
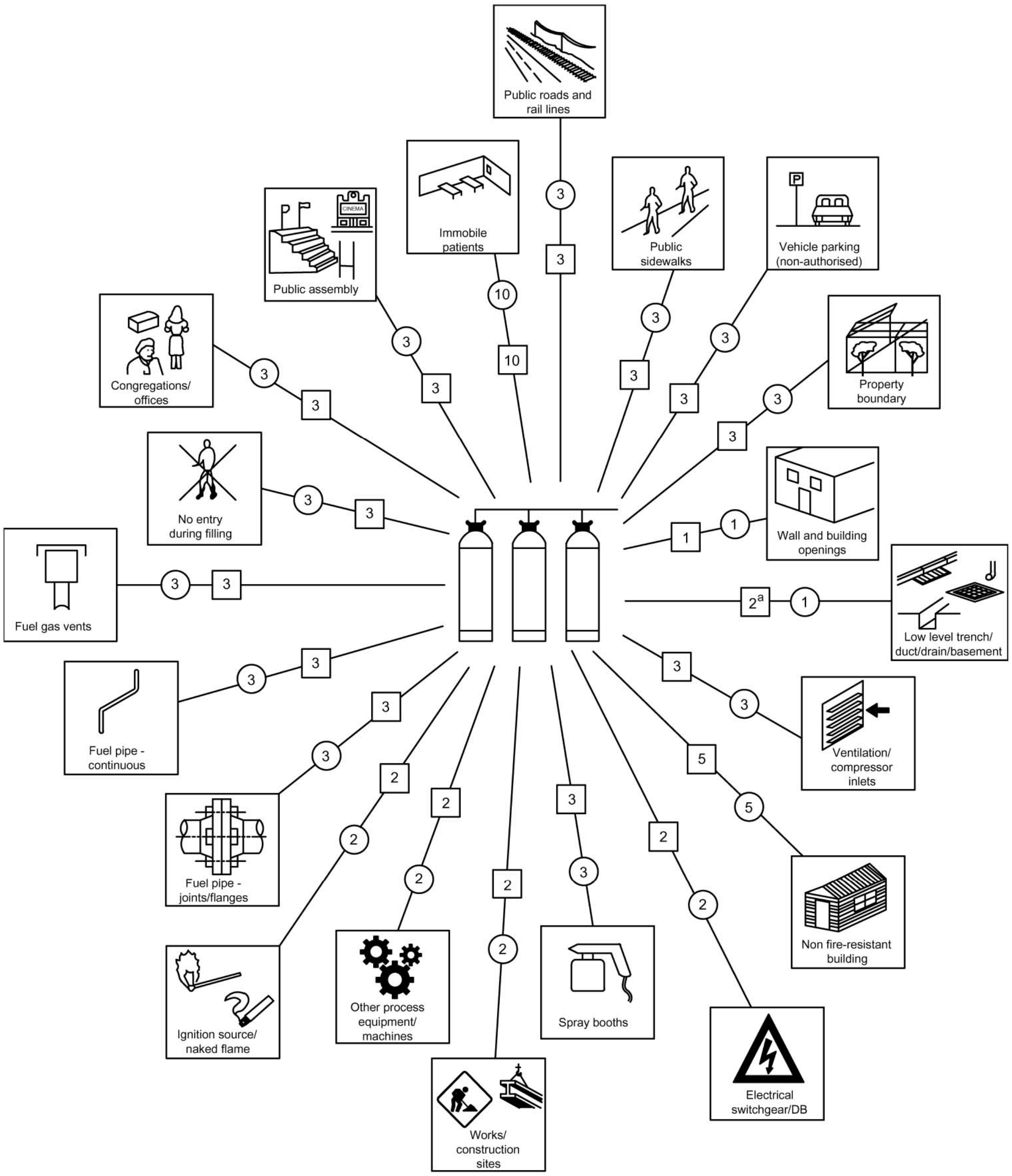



**Figure 4 — General safety distances from cryogenic supply**




NOTE Refer to SANS 10087-3.

**Figure 5 — Safety distances for storage facilities from cryogenic supply**




① Distance in metres when source is oxygen

[1] Distance in metres when source is inert

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**Figure 6 — General safety distances from compressed gas supply**

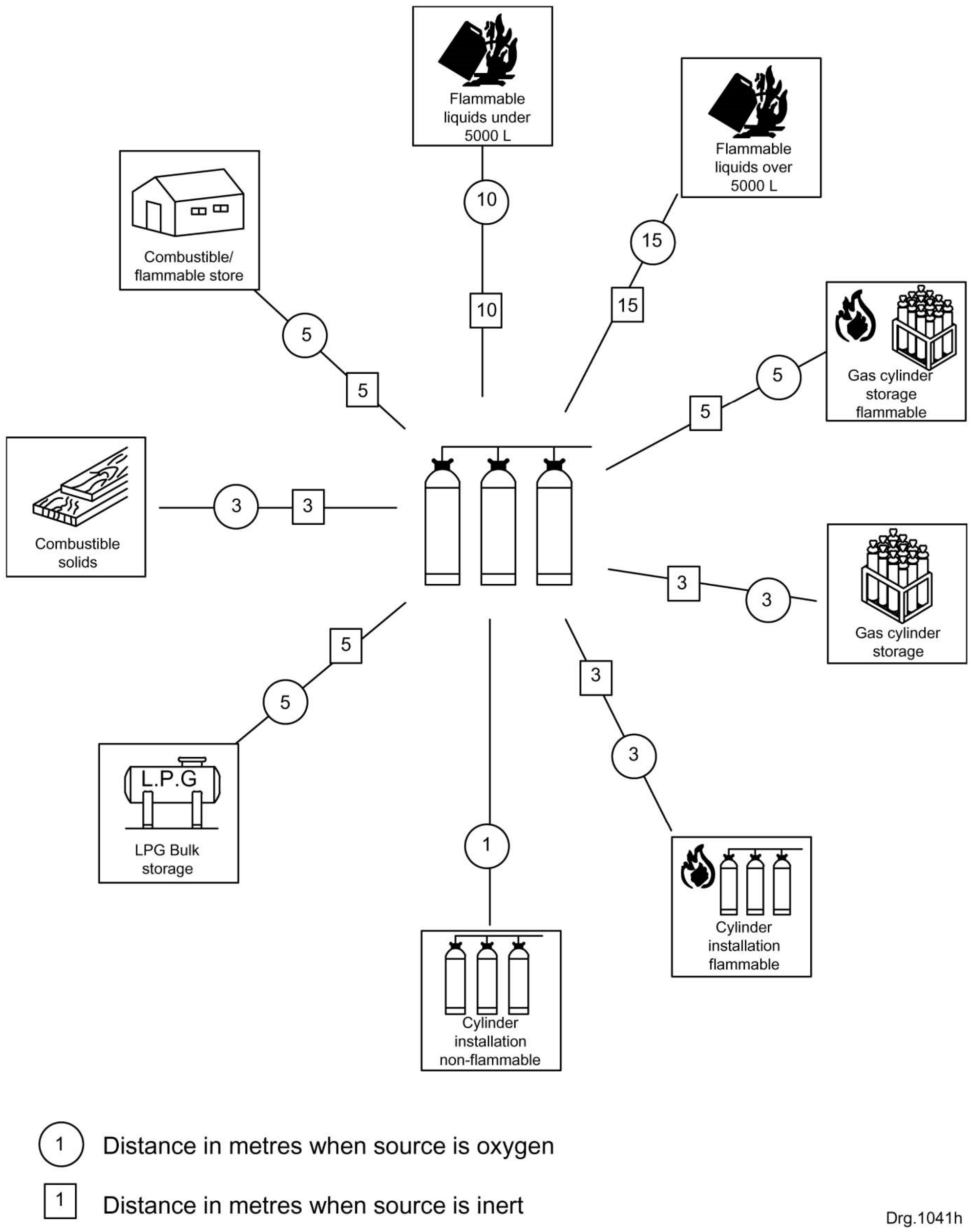


**Figure 7 — Safety distances for storage facilities from compressed gas supply**

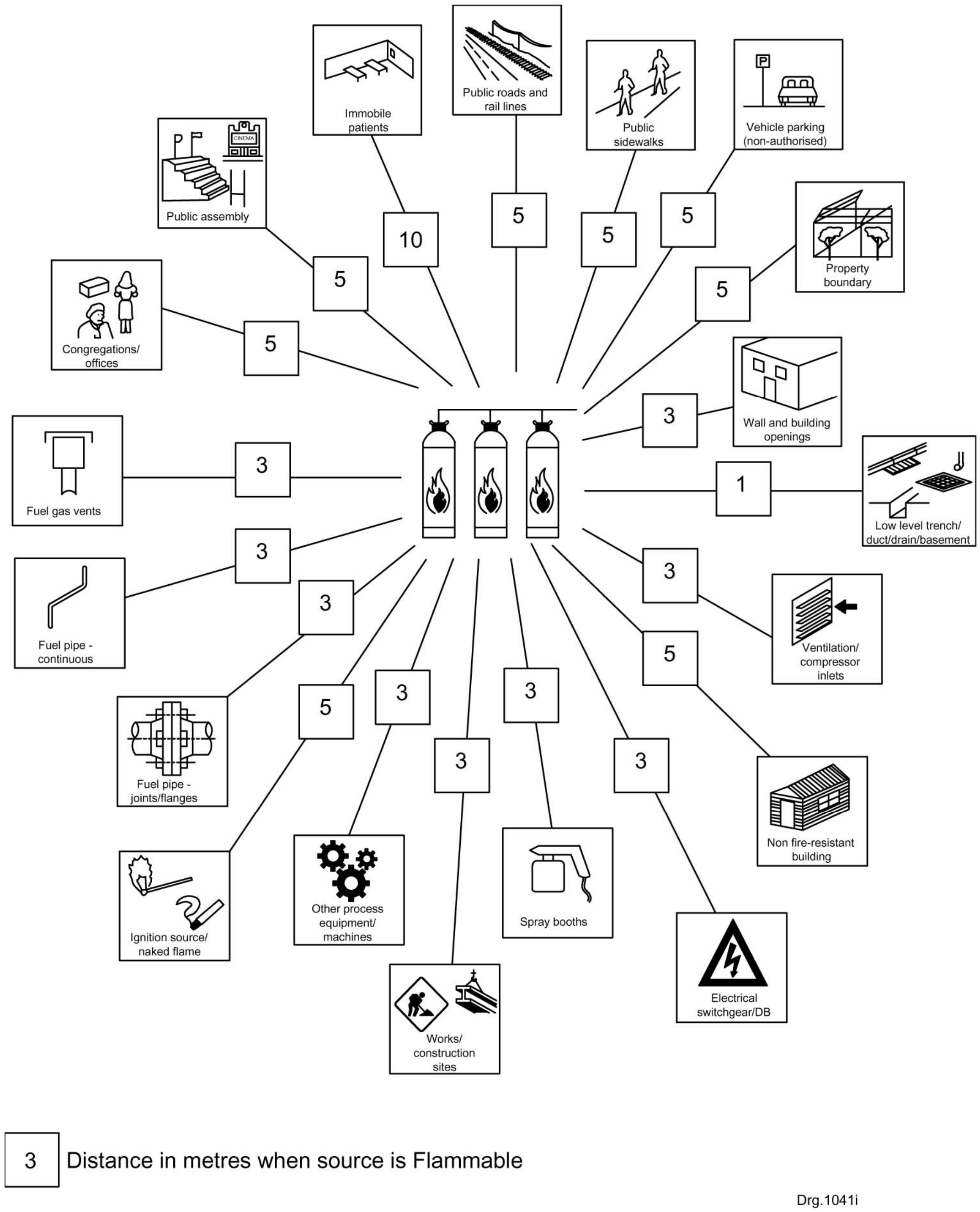


**Figure 8 — General safety distances from compressed flammable gas supply**

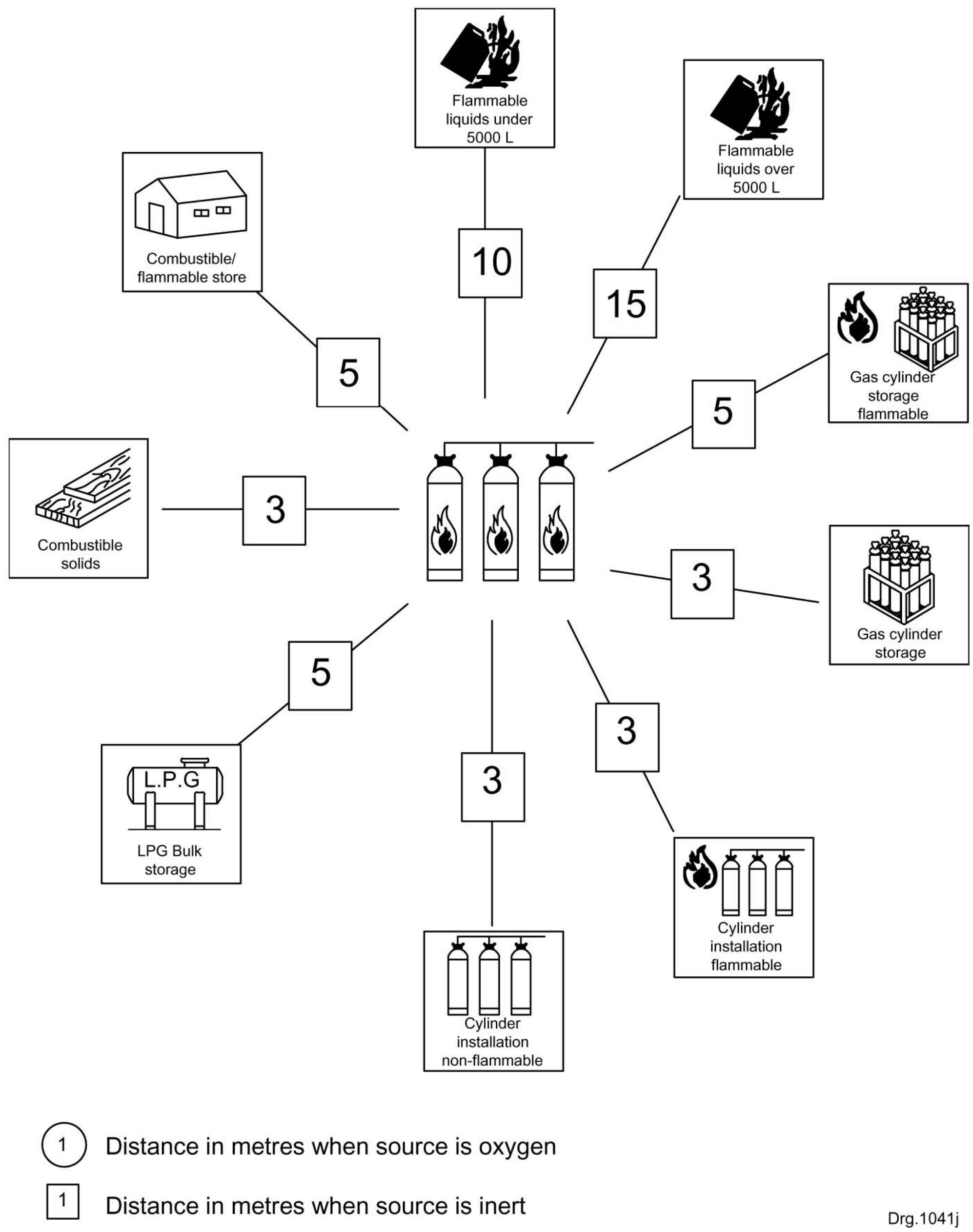


**Figure 9 — Safety distances of storage facilities from compressed flammable gas supply**

**6.2.1.3** The distances given in table 3 are minimum safety distances. Where the required minimum cannot be achieved in the horizontal plane, fire-resistant walls to a height of 2 m, built of materials and to a construction in accordance with SANS 10400-T, shall be used. The safety distance may then be measured as the shortest distance around the ends of the wall to the installation (see figure 10). Additionally, consideration shall be given to the density of the gas when considering safety distances.

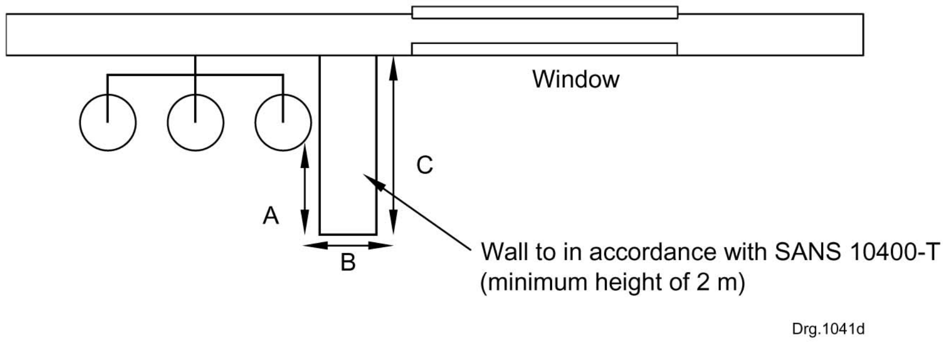


**Figure 10 — Measurement of safety distances**

### 6.2.2 Location of supply system

#### 6.2.2.1 Outdoor manifolds

Where the manifold is outside a building the following shall be observed:

a) Dependent upon the product and upon the security of the site, it may be sufficient to secure the manifold against a building wall.

b) Where site security may be an issue, consideration should be given to the provision of a suitable mesh cage or similar well ventilated security enclosure. Such installations shall also be in well ventilated locations away from occupied areas and meet the safety distance criteria for the product to be used.

c) Where manifolds are mounted against or on building walls, the walls shall be of fire-resistant materials complying with SANS 10400-T.

d) Where security enclosures are used the gates should not be self-locking, should be outward opening and provide easy access and egress.

e) The base of the location beneath the cylinders, bundles or cryogenic containers shall be of concrete or non-porous material and where applicable, shall be oxygen compatible.

f) Surfaces shall be even and shall provide adequate drainage so that cylinders or containers do not stand in water. Any slope should be such that cylinders are stable.

g) The base shall be of sufficient strength to take the weight of the cylinders, bundles or cryogenic containers.

h) In some instances it may be necessary to erect fire walls in order to comply with the safety distances. When this is the case, outdoor installations shall not be enclosed by walls on more than three sides.

i) Cryogenic supply vessels shall not be installed on the roof of buildings.

**6.2.2.2 Manifold rooms**

**6.2.2.2.1** Where a manifold is to be sited indoors, this shall be in a specially constructed building or in an established building which comply to the safety requirements of this sublause. No unauthorised access shall be allowed into manifold rooms and it shall be strictly for the use of cylinder and cryogenic containers. Equipment not related to the gas supply or distribution system shall not be located or operated within the manifold room.

**6.2.2.2.2** Where manifolds are installed in an existing building, they shall be separated from the rest of the building by means of a wall built to roof level, of fire-resistant material in accordance with SANS 10400-T and one wall of the manifold room should be an outside wall.

**6.2.2.2.3** For flammable and oxidizing products, the walls of manifold rooms shall be constructed of fire-resistant materials and the floor of concrete or a similar inorganic non-combustible material.

**6.2.2.2.4** The room should have a suitable access door designed to allow easy level access for cylinder movements and ideally have a second emergency escape door. One of these doors should be on an outside wall.

**6.2.2.2.5** Ideally two sides of the room should be ventilated, preferably on opposite sides. It is acceptable practice to have one wall in wire mesh incorporating the entrance doors and to have high and low level ventilation in the opposite wall. Where the room is part of an existing building, the ventilation shall be arranged such that ventilated air is not drawn into the building.

**6.2.2.2.6** The room shall be well ventilated to prevent the build-up of gases if leakage should occur and where different gases are used in the same room, both high and low level ventilation may be required.

**6.2.2.2.7** The roof shall be designed to prevent any build-up of lighter than air gases and where a pitched roof is used this should be vented at the apex (for example, a continuous ridge vent). Both entrance and escape doors (where fitted), should open outwards, should not be self-locking and should provide easy means of escape from within at all times. The main problem related to the siting of manifolds within a building is the inventory of gas within the cylinders or cryogenic containers, which in the event of a leak could create an asphyxiating, flammable or oxygen enriched atmosphere. However there are circumstances where it may be acceptable to position manifolds inside buildings, for example in large fabrication shops where the volume of the building is such that there is no possibility of an asphyxiating or oxygen enriched atmosphere occurring.

**6.2.2.2.8** Where manifolds are to be sited indoors, a risk assessment shall be carried out to determine the level of risk which may occur in such an area in the event of a leak i.e. asphyxiating, flammable or oxygen enriched atmosphere. The accepted limits of oxygen concentration in the atmosphere for normal working are above 19,5 % and below 23,5 %. For flammables a level of 25 % of the lower explosive limit should trigger an alarm. (For $CO_2$ the level accepted for normal working is less than the mass fraction of 0,5 % (5 000 ppm).

**6.2.2.2.9** The risk of asphyxiation or oxygen enrichment shall be considered. For the recommended concentration calculations to be undertaken to determine if a manifold system can be sited inside a room see annex K. For toxic and flammable gas installations, experts should be consulted with regards to the safe installation inside a room.

**6.2.2.2.10** The number of cylinders in the room should be the minimum necessary for the operation and safety distances between different types of gases shall be observed.

**6.2.2.2.11** Where flammable gas manifolds are installed, electrical systems and lighting in the manifold room shall be in accordance with the requirements of SANS 10108 and SANS 10142-1.

**6.2.2.2.12** Heating should be by steam or hot water. Combustion based heaters shall not be used within the manifold room.

**6.2.2.2.13** Flammable gas manifolds and pipework shall be electrically earthed in accordance with the requirements of SANS 10108 and SANS 10142-1.

**6.2.2.3** The installation shall be clearly identified with the product name and hazards in accordance with the requirements of the relevant national legislation (see foreword) and SANS 1186-1, either on the outside of a manifold room or adjacent to an outside installation.

### 6.2.3 Outlet point

Where there is a perceived risk of flammable, oxidizing or asphyxiating atmosphere forming at the outlet point connection, a risk assessment shall be conducted to establish the necessary controls to minimize the risk.

## 6.3 Distribution pipework design

### 6.3.1 Pressure drop

**6.3.1.1** For most conditions and gases within the scope of this part of SANS 10260, pressure drop (at 15 °C) can be estimated from the following equation:

$$\Delta P = P_1 - \sqrt{P_1^2 - \frac{32Q^2LS_g}{d^5}}$$

where

$\Delta P$ is the pressure drop in bar;

$P_1$ is the inlet pressure in bar absolute;

$Q$ is the flow in cubic metres per hour ($m^3/h$) measured at 15 °C and 101, 3 kPa (1,013 bar);

$L$ is the pipe length in metres (m);

$S_g$ is the specific gravity of the gas under consideration (where $S_g$air = 1);

$d$ is the internal diameter of pipe in millimetres (mm).

NOTE The designer should take into consideration the differences between Normal Temperature and Pressure (NTP) and Standard temperature and Pressure (STP) properties of the gas.

**6.3.1.2** Pressure drop shall be increased due to fittings and components installed in the pipework. The usual method of calculating pressure drop, due to fittings and components, is to increase theoretically the pipe length to account for the fittings as shown in table 4.

**Table 4 — Calculating pressure drop due to fittings and components installed in pipework**

| 1 | 2 | | | | | |
|---|---|---|---|---|---|---|
| **Pipe size**<br>**nominal bore** (mm/Imperial) | **Equivalent length of straight pipe**<br>m | | | | | |
| | **Valves (Wide open)** | | | **Fittings** | | |
| | **Ball** | **Globe or Diaphragm** | **Angle** | **Tee (Through)** | **Tee (Branch)** | **Elbow** |
| 10 to 12 / ¼" | 0,6 | 4,0 | 2,5 | 0,4 | 0,9 | 0,4 |
| 15 to 22 / ½" | 0,7 | 7,0 | 4,0 | 0,6 | 1,2 | 0,6 |
| 25 to 28 / ¾" | 0,9 | 9,0 | 4,3 | 0,8 | 1,7 | 0,8 |
| 38 to 42 / 1" | 1,2 | 12,3 | 6,1 | 1,2 | 2,4 | 1,2 |
| 50 to 54 / 1½-2" | 2,3 | 18,0 | 7,6 | 1,5 | 3,6 | 1,5 |
| 70 to 80 / 2½-3" | 2,5 | 27,0 | 12,2 | 2,5 | 5,5 | 2,5 |

**6.3.1.3** Allowance shall be made at the design stage for future extensions and the resultant increased flow requirements. The allowance shall be documented in the design.

NOTE The calculations for pressure drop are applicable to metallic piping only and provide indicative values.

### 6.3.2 Velocity

For materials of construction of oxygen systems, the velocity of the gas shall be kept below the defined values as given in annex A. For most gases and conditions covered by this part of SANS 10260, velocity may be calculated using the following equation

$$V = \frac{358Q}{D^2(P + 1{,}013)}$$

where

$V$ is the velocity in m/s;

$Q$ is the gas flow-rate in cubic metres per hour measured at 15 °C, 100 kPa (1 bar absolute);

$D$ is the internal diameter of the pipe in millimetres (mm);

$P$ is the inlet pressure in bar gauge (barg)

NOTE To convert the inlet pressure ($P$) in bar gauge (barg), 1,013 is added to convert to absolute pressure (barA).

# 7 Material and component selection

## 7.1 Materials of construction

For the specific gases covered in this part of SANS 10260, suitable materials are defined in annexes A to I. The system designer shall ensure that suitable materials are selected for the installation. The installer shall ensure that the specified materials are used in the construction of the installation and the suitable levels of cleanliness are established and maintained throughout the construction.

## 7.2 Flexible hose assemblies

**7.2.1** Flexible hose assemblies shall have end fittings permanently attached and where used on flammable gas systems be electrically conductive with a resistance not exceeding $10^6$ Ω to give protection against electrostatic charging.

**7.2.2** Hoses shall be suitable for the system design pressure, compatible with the service gas and the length and diameter shall be kept to a minimum.

**7.2.3** Where the pressure exceeds 4000 kPa (40 bar) anti-whip wires shall be fitted to prevent injury to personnel in the event of a hose failure.

**7.2.4** Hose assemblies shall comply to SANS 14113 or an equivalent standard.

**7.2.5** Pigtails shall be made from materials suitable for the gas and pressure.

## 7.3 Manifold

Typically this is made from materials suitable for the gas and pressure.

## 7.4 Regulators

Regulators shall be suitable for the system design pressure, flow rate and specified product. Regulators shall be suitably labelled to provide clear indication of the regulators intended service.

## 7.5 Pressure gauges

Pressure gauges shall comply with SANS 1062 for the operating requirements of the particular gas service.

## 7.6 Pressure relief devices

**7.6.1** Pressure relief valves shall comply with ISO 4126-1 or an equivalent design standard and shall be sized to ensure that the pressure in the system cannot exceed the system design pressure. A momentary over-pressure not exceeding 10 % of the set pressure is permitted to allow for the lifting characteristics of the valve.

**7.6.2** Bursting discs shall comply with ISO 4126-2 or an equivalent design standard. When fitted alone bursting discs shall be selected so that the pressure rating taking into account maximum tolerance, will not allow the pressure in the system to exceed the system design pressure by more than 10 %.

**7.6.3** Pressure relief devices shall be properly secured. Relief device outlets shall be located to relieve in a safe area. Where vent pipes are used, they shall be adequately sized to relieve the flow rate, be securely anchored to prevent movement and routed to discharge to a safe place.

**7.6.4** Certification for safety devices shall be provided by the supplier.

**7.6.5** Certification as well as inspection and testing of safety devices shall conform to the requirements of the relevant national legislation (see foreword).

**7.6.6** Isolatable portions of a supply scheme could possibly contain gas in the liquid phase shall be protected by a non-isolatable relief valve.

### 7.7 Isolation valves

**7.7.1** Isolation valves shall be designed for positive shut-off and should be identified by type for pressure rating, direction of flow and gas service. Fire-safe valves shall be considered for flammable gas systems.

**7.7.2** Specific gas service restrictions are specified in annexes A to I.

**7.7.3** Isolation valves should be fitted at strategic points on all main and branch lines so as to be readily accessible for emergency isolation.

### 7.8 Non-return valves

**7.8.1** Non-return valves should be capable of passing the required flow rate without oscillation or excessive pressure drop.

**7.8.2** Consideration shall be given to the required performance capability of a non-return valve with respect to the specific application including cracking pressure, seat leakage and reseating pressure. This is especially important where cross or back feed contamination can occur.

**7.8.3** Where non-return valves are used, for example in multi-cylinder manifolds, primarily as safety devices to prevent high pressure gas flowing back through open-ended flexible hoses, absolute leak-tightness against back flow may not be required.

### 7.9 Flashback arrestors

Flashback arrestors shall be suitable for the required flow and product.

### 7.10 Filters

**7.10.1** Filters should be installed to protect downstream equipment from particles. Filters shall be compatible with the product and system design pressure.

**7.10.2** Additional consideration shall be given to the filtration requirements of oxygen systems to prevent the possibility of loose particles forming ignition sources through impingement or frictional heating.

## 8 Construction, installation and testing

### 8.1 Pipe bends

**8.1.1** Bends shall have the same or higher design strength than straight pipe sections.

**8.1.2** Pipes should have a minimum bend radius of 3D (where D is the nominal pipe bore).

**8.1.3** Fabricated bends shall not be used.

## 8.2 Flanges and fixings

**8.2.1** Flanges shall comply with SANS 1123 or a relevant international standard in respect of material, dimensions and drilling and be suitable for the duty for which they are installed.

**8.2.2** Nuts and bolts shall comply with the relevant parts of the SANS 1700 and be suitable for the duty for which they are installed. Bolts and stud bolts shall extend completely through the nuts by at least two full threads.

## 8.3 Jointing materials

**8.3.1** The design shall specify the joint sealing material to be used. Jointing materials shall be capable of withstanding the maximum pressure and maintaining their chemical and physical properties at any temperature which may be experienced in service.

**8.3.2** All types of jointing material shall be suitable for the particular gas service.

**8.3.3** Only oxygen compatible PTFE tape shall be used as a sealant for threads for all gas types. BS 7786 may be used as a guideline for PTFE tape.

**8.3.4** Asbestos based jointing materials shall not be used.

## 8.4 Pipe fittings

Pipe fittings shall be capable of withstanding the system design pressure and shall be compatible with the service gas.

## 8.5 Compression fittings

**8.5.1** Only compression fittings designed and approved by the original equipment manufacturer (OEM) for the specific gas application and service shall be used. Domestic plumbing fittings and piping may not be used in gas installations.

**8.5.2** Compression fittings should not be used in systems where they may be exposed to wide temperature variations.

**8.5.3** Only compression fittings up to a maximum diameter of 15 mm, designed and approved for the specific gas service, shall be used.

**8.5.4** Where this method of jointing is used, the requirements of SANS 10400-T shall be observed in relation to routing of pipework through ducts, roof voids and similar confined spaces.

**8.5.5** The manufacturer's installation instructions shall be followed when compression fittings of any type or size are used.

## 8.6 Pipe jointing

**8.6.1** Pipes shall be joined by one of the following techniques:

a) Carbon steel - welded, bronze welded, flanged, screwed or compression fittings.

b) Copper and copper alloys - brazed, bronze welded, flanged, screwed, compression fittings. Soft-soldered joints shall not be used.

c) Stainless steel - welded, brazed, flanged, screwed compression fittings.

**8.6.2** Jointing techniques shall be used only after detailed evaluation and risk assessment.

## 8.7 Jointing techniques

### 8.7.1 Welding

All welding shall be done in accordance with the following (as relevant):

a) BS 2971;

b) BS 2633;

c) BS 4872-1;

d) BS 4872-2;

e) ISO 287;

f) ASME BPVC-IX; and

g) SANS 15607.

### 8.7.2 Brazing

**8.7.2.1** Where appropriate and in accordance with EN 13134, joints for BS 1306 piping systems or ASME BPVC-IX for ASME B31.3 piping systems shall be made with the appropriate brazing alloy and flux.

**8.7.2.2** Pipe ends shall be square cut with full penetration into the end fitting and a minimum wetted area of 70 % or in accordance with the brazing procedure.

**8.7.2.3** Brazers shall comply with ISO 13585.

**8.7.2.4** In cases where flux residues are not acceptable, copper phosphorus rod may be used for flux less brazing of copper to copper using a suitable purge.

### 8.7.3 Screw threads

**8.7.3.1** Screw threads shall comply with SANS 1109-1 or to an relevant international standard where the pressure seal is made on the thread. For threads where the seal is not made on threads, SANS 1306-1 or relevant international standard will apply.

**8.7.3.2** Threads shall be clean cut and the calculated strength of the threaded joints shall be adequate for the pressure and other service loading of the pipework in which they are installed.

**8.7.3.3** The number of threaded joints shall be kept to a minimum.

**8.7.3.4** Taper and parallel threads and threads should not be mismatched unless allowed by the relevant standards. Threads of different forms shall not be mismatched.

**8.7.3.5** PTFE tape shall only be used on taper threads, it should only be applied sparingly and start at least one thread back from the start of the thread form. Only oxygen grade PTFE tape shall be used on oxygen systems.

**8.7.3.6** Under no circumstances should thread tape be in direct contact with the gas stream.

## 8.8 Supports

**8.8.1** Supports shall be capable of supporting the pipe system without causing distortion.

**8.8.2** Supports shall be adequate for the concentrated loads imposed by valves and risers and for axial loading due to thermal expansions/contractions and the pressure of the gas.

## 8.9 Routing

### 8.9.1 General

**8.9.1.1** All pipework shall be adequately supported and protected where necessary from damage, vibration or corrosion.

**8.9.1.2** Sections of pipework in buildings should be kept to the minimum reasonable practicable length. Where pipes have to be run inside buildings they should be run in well ventilated rooms and mechanical joints should be kept to an absolute minimum.

**8.9.1.3** SANS 10400-T provides guidance to designers in relation to fire protection in service ducts. Gas pipelines shall not be routed in or through ducts provided for ventilation purposes.

**8.9.1.4** BS 8313 provides guidance relating to the accommodation of building services in ducts. This standard divides gas vapour and liquid pipework into groups according to the major risk associated with the pipework contents. BS 8313 recommends that hazardous materials such as flammable, oxidizing, toxic or corrosive gases or liquids should only be run in ducts when there is no safe practical alternative.

### 8.9.2 Routing in ducts

**8.9.2.1** There shall be no routing of gas pipelines in or through ducts and shafts provided for ventilation services.

**8.9.2.2** Routings in enclosed spaces (roof and floor spaces, ducts, etc.) should be avoided. Where pipes have to be routed through enclosed spaces, they shall be installed in accordance with SANS 10400-T.

**8.9.2.3** The pipe shall be of non-combustible material with a melting point not lower than 800 °C.

**8.9.2.4** Joints shall be welded or brazed (see 8.7) and strength tested.

**8.9.2.5** The duct shall be well ventilated such that a hazardous atmosphere cannot develop within the duct or by some other means that ensures a hazardous atmosphere cannot develop within the duct.

**8.9.2.6** There shall be no mechanical joints within the enclosed pipe run.

**8.9.2.7** Where it is necessary to install flammable gas pipework in service ducts the flammable gas pipework shall not be installed in the same duct as any other services other than cold water or steam.

**8.9.2.8** Pipes conveying oxidizing gases should only be run in service ducts with possible exposure to leakage of incompatible materials, for example, from oil or flammable materials.

**8.9.2.9** Where it is not possible to ventilate ducts, pipework shall be run within an outer, larger diameter pipe, (i.e. sheathed), both ends of the outer pipe being open to well ventilated positions.

**8.9.2.10** Routing of flammable, oxidizing or inert services through cavities should be avoided where practicable, but, if this is necessary, the following requirements shall be observed:

a) Services should take the shortest practicable route through the cavity.

b) The use of high-integrity pipework, avoiding joints within the cavity is recommended.

c) Where a pipe penetrates a fire resisting division or enclosure, the pipe shall be sleeved. The fire resistance of the material used for the sleeve shall be at least equal to that of the materials forming the cavity. The sleeve shall be sealed to the structure using suitable building materials and the pipe shall be sealed.

## 8.10 Underground routing

**8.10.1** Flammable and oxidizing gases should not be run in the same trench or duct unless:

a) the ventilation is adequate for example, in a large ventilated duct;

b) the trench is back filled with an inert non-corrosive material and the oxygen and flammable gas lines have a minimum separation distance of 300 mm; or.

c) the lines are encased in concrete and the oxygen and flammable gas lines have a minimum separation distance of 300 mm.

**8.10.2** Inert gases may be run in the same trenches as either oxidizing or flammable gases.

**8.10.3** Piping shall be at least 150 mm away from any electrical power cables.

**8.10.4** Mechanical joints shall not be used underground. Joints shall be welded or brazed and tested in accordance with 8.7.

**8.10.5** Flanges or other mechanical joints shall only be permissible when they are essential for assembly and disassembly.

**8.10.6** Where valves are used, they should be accessible from the surface (via a suitable access pit, for example, concrete or brick lined) and be of a high integrity leak tight design.

**8.10.7** Where the piping is to be laid underground on private property under tarmac or grass areas where there is no likelihood of heavy traffic, the pipe shall be at least 600 mm deep (measured to the top of the pipe) (see figure 11).

**8.10.8** Where the pipe is to be laid under a road, the pipe shall be a minimum of 600 mm deep (measured to the top of the pipe).

**8.10.9** Where subsidence may be a problem, consideration should be given to using concrete slabs or steel plates positioned on a bed of sand above the pipe.

**8.10.10** Where the ground at the base of the trench is of irregular consistency, the depth of excavation should be increased by approximately 75 mm in order to allow the pipe to be laid on a bed of sand.

**8.10.11** Pressure testing should take place prior to back-filling, although this is not essential if all joints and connections are left exposed for such tests.

**8.10.12** The backfill at the sides of the pipe and immediately above it should be of the same material as that used under the pipe.

**8.10.13** The initial cover of backfill over the pipe should be carried out by hand and compacted such that there is a good support between the sides of the pipe and the trench and a firm layer over the top of the pipe.

**8.10.14** Where piping is to enter a building, the entry point should be above ground wherever this is practicable.

**8.10.15** Pipework shall not pass under the foundations of the building, under the base of a wall or under the footings.

**8.10.16** Where the pipework passes through the wall of the building, a metal sleeve shall be used and where appropriate, the same principles of construction used as if the pipework were passing through a cavity.

## 8.11 Pipework

**8.11.1** Pipework should only be installed underground where there is no alternative.

**8.11.2** Several different methods may be used as follows:

a) pipes installed on pipe racks or supports inside concrete or metal ducts, which may be closed by the use of masonry slabs or which may be covered using open grid covers;

b) pipes laid in trenches and backfilled with suitable material; and

c) pipes laid in trenches and encased in concrete.

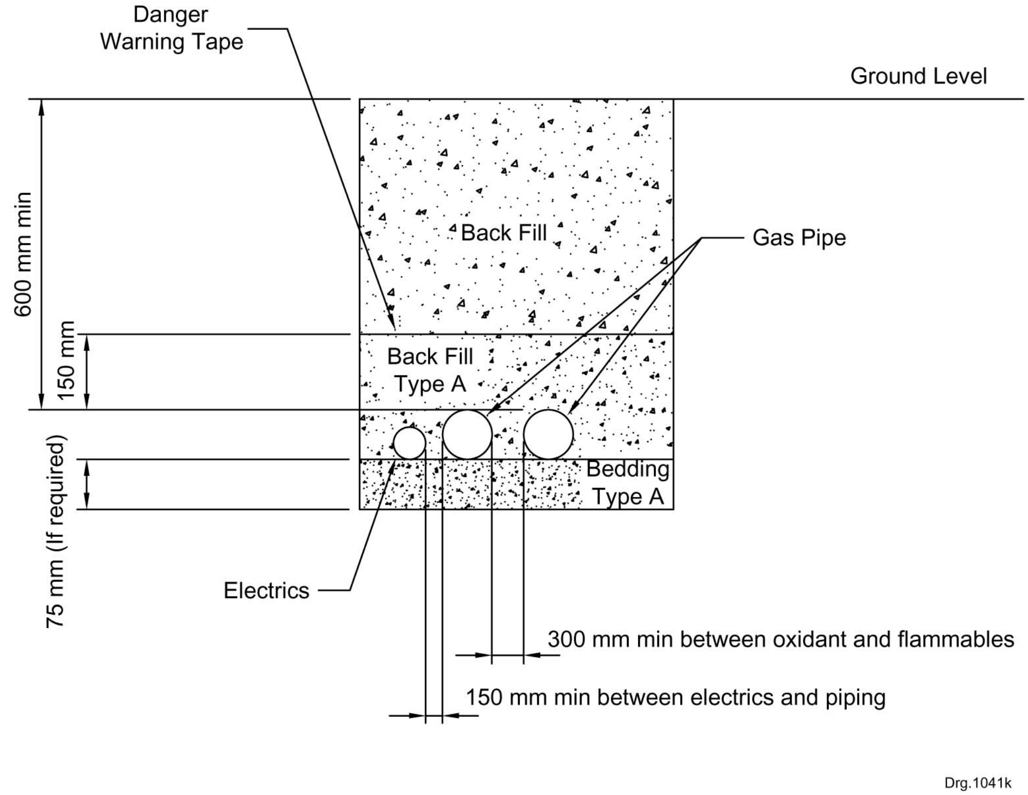


**Figure 11 — Guideline for general arrangement of underground gas piping**

## 8.12 Corrosion protection

### 8.12.1 General

Due consideration shall be given to potential galvanic corrosion of conductive pipelines in the region of railway lines, power stations and large electrical components as well as any corrosive environmental conditions.

### 8.12.2 Painting

Where painting is required, this should be done in accordance with manufacturer's recommendations on clean, dry and rust-free surfaces and shall comply with SANS 10140-3.

### 8.12.3 Wrapping

For buried pipework or in corrosive atmospheres, a protective wrapping shall be applied. The protection shall be applied as a continuous wrap with sufficient overlap to prevent exposure of the pipe surface. Pipework laid in open trenches shall be painted where necessary.

### 8.12.4 Cathodic protection

A cathodic protection system may be installed to counteract the corrosive nature of the terrain or to neutralize possible galvanic effects. This is usually installed by a specialist contractor in accordance with SANS 10108 or an equivalent standard.

## 8.13 Cleaning

**8.13.1** Pipes, fittings and equipment shall be fully cleaned and degreased before erection and cleanliness maintained thereafter.

**8.13.2** Certain gases such as oxygen require special cleaning methods. It is recommended that all pipework, valves and fittings exposed to the product are obtained from a supplier with the capability of cleaning to ASTM G93 or EIGA IGC 33 or recognised/authorised procedure. Alternatively, specialist-cleaning companies may be used.

**8.13.3** Site cleaning of pipework should be limited to re-cleaning ends of pipework or valves and fittings which may have been contaminated during the system erection process.

NOTE Relevant health and safety precautions and relevant legislation (s) should be followed when using and disposing of solvents or cleaning agents.

**8.13.4** Completed pipework shall be cleaned internally until all foreign matter is removed. This shall be achieved by passing clean, dry, oil-free nitrogen through the pipework at high velocity.

## 8.14 Identification

**8.14.1** Each pipe shall be identified in accordance with SANS 10140-3.

**8.14.2** Where the precise nature of the pipe content is important, a secondary identification should be superimposed on the basic identity either by written word, gas symbol or secondary colour.

## 8.15 Testing

### 8.15.1 General

**8.15.1.1** Pressure gauges and safety devices may have to be removed from the system before testing.

**8.15.1.2** Safety devices shall be tested prior to installation by the manufacturer.

**8.15.1.3** Parts which have been tested prior to installation may be excluded from the pressure test on the final inspection.

### 8.15.2 Pressure test

**8.15.2.1** Particular equipment design codes will have specific pressure testing requirements.

**8.15.2.2** Equipment may also be required to comply with the relevant national legislation (see foreword).

**8.15.2.3** New equipment and piping requires a designed pressure test and a functional pressure test.

**8.15.2.4** Repaired or refurbished equipment requires a leak test (as the equipment should have already had a design pressure test when it was manufactured) and a function test.

**8.15.2.5** A minimum of 30 min retention time is required for a pressure test.

**8.15.2.6** A leak test may be done in conjunction with a design pneumatic test.

### 8.15.3 Test medium

**8.15.3.1** Equipment should be hydraulically tested wherever possible, as the energy released in the event of a failure compared with a pneumatic test is considerably lower.

**8.15.3.2** Pneumatic testing should only be carried out when hydraulic testing is not practicable, for instance where the interior of the pressure equipment will be contaminated by the hydraulic test medium. A suitable risk assessment shall be conducted prior to carrying out a pneumatic test as specified in the relevant national legislation (see foreword).

**8.15.3.3** For hydraulic testing demineralized water with a chloride content of less than 50 µg/g should be used. The use of potable water as a test medium is not recommended, owing to the risk of producing rust through oxidation and to the difficulty of obtaining the required low moisture content and purity of the gas distributed.

**8.15.3.4** For pneumatic testing, clean, dry, oil-free inert gas such as nitrogen shall be used.

### 8.15.4 Determination of the test pressure

**8.15.4.1** Test pressure is a function of the system design pressure of the equipment.

**8.15.4.2** For systems connected to a high pressure source for example, a compressed gas cylinder, the system design pressure shall be the developed pressure of the cylinder at a reference temperature of 65 °C (see SANS 10019 for table of developed pressures).

**8.15.4.3** For other systems the system design pressure shall be at the lowest pressure rated component in the system or at the highest setting of a protective device protecting the system.

**8.15.4.4** The test pressure for a hydraulic pressure test shall be 1,5 times the maximum working pressure or 1,1 times the maximum working pressure for a pneumatic pressure test.

**8.15.4.5** Whatever pressure test is to be performed and the fluid used, a risk assessment shall be carried out and documented.

## 8.16 Commissioning

### 8.16.1 Anti-confusion test

Where, for any reason, cross-connection of the pipework is possible, the following anti-confusion check shall be made:

a) isolate the pipework from all gas supplies except the one under test, then;

b) check that gas is supplied at each outlet point of the pipework under test;

c) no gas is supplied into the system or from the outlet points of any other system; and

d) prove each pipework supply and distribution system in turn with all other systems isolated.

### 8.16.2 Purging into service

All systems shall be purged with an inert gas before introducing the service gas systematically into the system.

### 8.16.3 Service tests

**8.16.3.1** Check non-return valves and stop valves for closure tightness and gland leakage.

**8.16.3.2** Check manifold changeover valves for closure tightness and gland leakage. Automatic changeover devices should also be checked for correct operation.

**8.16.3.3** Check alarm and cut-off devices for correct operation and set pressure.

## 8.17 Precautions

**8.17.1** Before connecting gas cylinder bundles or cryogenic containers, ensure that there are no particles of dirt in the cylinder outlet.

**8.17.2** Carefully inspect the outlet and if there are any signs of dirt or wipe with clean, oil free, lint free cloth.

**8.17.3** Ensure that the cylinders or containers to be connected are correctly identified for the system for example product and pressure.

**8.17.4** Ensure that all equipment to be connected to the system is suitable for the maximum operating pressure that can be applied and the service gas.

**8.17.5** Correct tools should be used to tighten supply connections and valves to avoid damage and over torque.

**8.17.6** Always open valves slowly when connected to the gas supply. An open valve should not be left less than half a turn from the fully open position.

**8.17.7** A flame test for detection of leaks shall not be used.

## 8.18 Provision of information

**8.18.1** The designer, supplier or the employer of a person who installs, modifies or repairs a pressure system shall provide sufficient written information to enable the user of a pressure system to determine the safe operating limits within his responsibility in accordance with the relevant national legislation (see foreword). Such information may include the following:

a) design codes;

b) process and instrumentation drawings or flowsheets;

c) safe operating limits for pressure and temperature;

d) system design pressure and design temperature;

e) operating instructions (including emergency procedures);

f) written scheme of examination;

g) maintenance instructions;

h) test, material and compatibility certificates;

i) Certificate of Conformity; and

j) for flammable or oxidizing gas systems a risk assessment.

**8.18.2** Relevant information should be included in the handover documentation or operating instructions supplied to the user.

# 9 Use of the pressure system

## 9.1 General

Details of the duties of the user in relation to the operation, examination, repair and maintenance of the system and of the need for the user to obtain a written scheme of examination (if applicable) for the system and keep certain records are given in 9.2 to 9.6 (inclusive).

## 9.2 Operation — Information and training

**9.2.1** Relevant instructions shall be provided to indicate operation of controls. A system flowsheet and a piping and instrumentation diagram (P& ID) shall also be made available.

**9.2.2** Hazard warning notices appropriate to the installation shall be clearly displayed together with telephone numbers for emergency contact.

**9.2.3** The supplier shall provide the user with information on operating conditions and these shall not be changed such that safe working could be jeopardized. Any change shall be approved by an authorised person.

**9.2.4** All operators shall receive relevant instructions and training before operating manifolds and pipes. The training records shall be kept by the user.

## 9.3 Maintenance

### 9.3.1 General

**9.3.1.1** The user shall ensure that maintenance is carried out as specified in the relevant national legislation (see foreword).

**9.3.1.2** Maintenance covers a wide range of activities ranging from such items as servicing, lubrication, adjustment, performance checks and painting through to routine safety inspections.

**9.3.1.3** The maintenance schedule for a system should cover the points given in 9.3.1.4 and 9.3.1.5 as a minimum requirement. Inspection should be carried out by a person with appropriate knowledge and experience.

**9.3.1.4** Planned maintenance of the gas supply system should be carried out periodically (for example annually) and the date recorded. This should include at least the following:

a) checking safety distances;

b) ventilation;

c) fire-fighting equipment;

d) means of access;

e) floor condition;

f) replacement of flexible connecting hoses (if any) at appropriate intervals;

g) checking of control equipment and safety devices for damage and correct operation;

h) checking of all pressure gauges for correct indication, damage and security of attachment;

i) checking all equipment for leakage; and

j) replacement of all defective and illegible warning notices.

**9.3.1.5** To maintain the correct function and safety of the pipeline system, it is necessary to carry out regular inspections. The inspection should ensure that at least the following have been checked:

a) that all changes made (including removals and additions of components) and all extensions carried out comply with this part of SANS 10260;

b) that changes in the vicinity of the installation do not affect its operation or safety (examples are: location of heat sources or burners; moving of machines or work places; occurrence of vibrations; illicit use of a pipeline as an electric conductor or as a support for other items; proximity to electrical installations and to other piping systems);

c) that adequate pipeline identification is present;

d) that there is no leakage (particular attention should be given to valves, to joints of all types, to connections and to areas of corrosion);

e) in the case of buried pipelines, that the ground is free from erosion, subsidence and encroachment by other services, buildings or civil structures (damage to cathodic protection should also be checked and readings, where applicable, should be recorded);

f) that filters are in good condition, are not blocked, and have been cleaned where necessary;

g) that valves used in normal operation, or in the event of an emergency, are accessible and are easy to operate (valves at service point outlets and vent valves are to be checked for leak tightness);

h) that the setting and operation of regulators are within the design and operation requirements of the pipeline system;

i) that relief valves for leak proof closure, for lifting pressure and security of vent pipe work are in good condition (operation of other safety devices, e.g. temperature controls and non-return valves, is also to be checked);

j) that warning notices are present and legible;

k) that the external finish of the pipeline and its protection against corrosion are acceptable;

l) pipeline and associated equipment are free from damage and acceptable for further use until the next maintenance inspection; and

m) that the non-return valve, incorporated in the outlet valve, does not leak.

**9.3.1.6** Terminal unit components shall be inspected at regular intervals, for example. annually, and faulty equipment shall be replaced as necessary.

**9.3.1.7** Where hoses are used for portable terminal units, they shall be inspected and replaced if damaged or at appropriate intervals.

## 9.4 Repair and modification

**9.4.1** The user shall ensure that the installation, repairs or modifications of a pressure system are carried out so as not to give rise to danger, or otherwise impairs the operation of any protective device (for example, pressure relief valve or bursting disc) or inspection facility.

**9.4.2** All repairs and modifications shall be carried out by a registered gas installer to the same design and construction standards as the original system, so as not to reduce its integrity. Full testing of the repaired or modified system will be required on completion (see 8.14).

**9.4.3** System records, flowsheets or schematics, general layout drawings, operating instructions will need to be updated following repair and modification. Consideration shall also be given to the need to amend the system safe operating limits.

## 9.5 Keeping of records

**9.5.1** The following records shall be kept by the user (or the owner in the case where he/she has undertaken to examine and maintain the system):

a) the Certificate of Conformity;

b) the last report in accordance with the Certificate of Conformity;

c) previous reports if they assist in assessing whether the system is safe to operate;

d) details of any repairs or modifications carried out;

e) documents supplied in 8.17;

f) agreement to postpone an examination and notification to the chief inspector; and

g) details of any out of service periods and storage conditions (where appropriate).

**9.5.2** These records shall be kept either at the premises where the equipment is installed or at the office of the user or owner when applicable. The records may be kept within a computer system as long as a printed copy can be produced when required. Records shall be kept for the lifetime of the installation.

## 9.6 The duties of the authorised person

**9.6.1** The relevant national legislation (see foreword) defines duties for the authorised person in three distinct functions as follows:

a) advising the user on the scope of the Certificate of Conformity;

b) issue and sign the Certificate of Conformity as in accordance with the relevant national legislation (see foreword); and

c) carrying out examinations under the relevant national legislation (see foreword).

**9.6.2** An authorised person is defined in the relevant national legislation (see foreword).

## 9.7 Certificate of Conformity

**9.7.1** The installed system shall not be operated without a Certificate of Conformity certified by an authorised person as specified in the relevant legislation (see foreword).

**9.7.2** The Certificate of Conformity shall declare the compliance of a system with this part of SANS 10260.

# Annex A
(normative)

# Oxygen

## A.1 General

This annex defines the properties and requirements for oxygen systems.

## A.2 General data

| | |
|---|---|
| Chemical symbol: | $O_2$ |
| Flammability: | Non-flammable (see A.4.1) |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive (in absence of moisture) |
| Density: | Ambient gas: Slightly heavier than air<br>Cold vapour: Much heavier than air |
| Colour: | Gas: Colourless<br>Cold Vapour: May form a white mist or fog cloud<br>Liquid oxygen: Light blue |
| Odour: | None |
| Taste: | None |
| Liquid boiling point: | -183 °C at 101,3 kPa - Absolute |
| Liquid to gas ratio: | 1:854 |
| NOTE 1 All gas mixtures containing more than 23,5 % oxygen should be treated as oxygen.<br><br>NOTE 2 For further information please refer to the EIGA IGC 13. | |

## A.3 Recommended materials

### A.3.1 Oxygen service material selection

**A.3.1.1** Oxygen service material selection depends on several factors including:

a) pressure;

b) temperature;

c) gas velocity;

d) cleanliness; and

e) particle inclusion.

**A.3.1.2** Failure to take these factors into account may result in a high risk of fire, explosion or pipeline rupture.

### A.3.2 Piping

**A.3.2.1** Carbon steel pipe in oxygen service shall be seamless. Stainless steel and other alloys may be seamed provided that the pipe is fabricated and tested to a recognised international standard. If seamed pipe is bent, the weld seam should be on the neutral axis and not on the inner or outer radius.

**A.3.2.2** General piping materials in order of preference are as follows:

a) copper and copper alloys;

b) stainless steel; and

c) carbon steel (minimum schedule 40).

**A.3.2.3** Exotic piping alloys are available for extreme oxygen service.

### A.3.3 Jointing

**A.3.3.1** Jointing and gasket materials for use in oxygen duty shall be certified suitable for the service conditions, and cleaned for oxygen use.

**A.3.3.2** Suitable materials are as follows:

a) virgin PTFE;

b) compressed fibre (oxygen compatible);

c) copper washers; and

d) viton bonded seals.

**A.3.3.3** Aluminium sealing washers shall not to be used for oxygen service.

### A.3.4 Cleanliness

Any material selected as suitable for use in oxygen service shall also be cleaned for oxygen duty. A suitable material may be dangerous in oxygen if it not cleaned properly.

## A.4 Special conditions

**A.4.1** Oxygen is non-flammable but it supports combustion vigorously. Oxygen in contact with most materials can result in the violent or explosive combustion of that material.

**A.4.2** All readily combustible materials can burn violently in oxygen, generating higher combustion temperatures and flame speeds. Materials such as oils, grease, solvents and finely divided particles shall not come into contact with oxygen. Very high levels of cleanliness are required for all components and materials that come into contact with oxygen. For guidelines on cleaning for oxygen duty (see EIGA IGC 33).

**A.4.3** All piping and components supplied for use with oxygen shall also be cleaned for oxygen service. Oxygen clean certification can be obtained by the supplier or the original equipment manufacturer (OEM).

**A.4.4** Installers shall ensure that piping, fittings, equipment or components have remained in the "clean" state until installed.

**A.4.5** For pipelines made of ferrous materials, including stainless steels and carbon steels, gas velocity shall be limited to the values in table A.1.

**Table A.1 — Requirements for gas velocity**

| 1 | 2 |
|---|---|
| **Pipeline pressure MPa (g)** | **Maximum velocity m/s** |
| Up to 1,6 | 25 |
| Above 1,6 to 1,8 | 19 |
| Above 1,8 to 2,0 | 17 |
| Above 2,0 to 2,2 | 15,5 |
| Above 2,2 to 2,4 | 14,5 |
| Above 2,4 to 2,6 | 13,5 |
| Above 2,6 to 2,8 | 12,5 |
| Above 2,8 to 3,0 | 11,5 |

**A.4.6** The velocities given in table A.1 shall not be exceeded. The velocities represent approximately 80 % of the values given in EIGA IGC 13.

**A.4.7** For oxygen pressures above 3 MPag (30 barg), pipeline design shall be in accordance with the requirements of EIGA IGC 13. The velocities above 3 MPag (30 barg) should be limited to the approximately 80 % of the values given in EIGA IGC 13.

**A.4.8** Ball valves in oxygen service should be avoided where possible. Where ball valves are used, they shall not be used in throttling or flow control service. Ball valves are only to be used as isolation valves, and shall be used as either fully open or fully closed. Reduced bore ball valves shall not be used.

**A.4.9** Sudden pressurisation of any section of the oxygen installation shall be avoided in both design and operation. Rapid pressurisation can lead to adiabatic compression of the oxygen downstream of the valve, which may raise gas temperatures to the point of causing a fire or explosion.

NOTE Adiabatic compression occurs when there is no heat transfer during the compression of a gas, either because of perfect insulation or because the change in pressure is so rapid that there is insufficient time for the heat, which is generated, to dissipate. This may happen if a valve in a system is opened too quickly, leading to rapid pressurization of the downstream system. This results in elevated temperatures and can lead to ignition in some cases, for example in oxygen systems.

**A.4.10** When operating valves in oxygen service, extreme care shall be taken to avoid high velocity gas flows, especially where the downstream pressure is significantly lower than the upstream pressure. Excessive oxygen velocities may result in fire or explosion.

**A.4.11** Rapid pressurisation of polymer lined manifold and pipeline hoses, or equipment containing polymeric compounds shall be avoided. Cylinder valves and isolation valves shall always be opened slowly and gently.

**A.4.12** Equipment and components used in oxygen service shall be suitable for oxygen. Certification of suitability for oxygen use under the specific service conditions can be obtained from the original equipment manufacturer.

**A.4.13** All lubricants used in oxygen service shall be certified suitable for oxygen use under the system conditions, and shall be used in accordance with the manufacturer's requirements. Certification of suitability shall be obtained from the lubricant manufacturer.

**A.4.14** No equipment used for other gas services may be marked for oxygen service.

**A.4.15** The internal surfaces of equipment, containers, components or pipelines that come into contact with oxygen shall not be painted.

**A.4.16** Under no circumstances may oxygen come into contact with tools, cleaning rags, or clothes that are contaminated by oils or hydrocarbons, as spontaneous ignition may occur.

**A.4.17** Oxygen shall not be used to replenish atmospheres or as alternative for compressed air.

**A.4.18** Pressure gauges used in oxygen service shall have sensing elements suitable for oxygen, and be suitably degreased. Pressure gauges in oxygen service shall bear the markings "OXYGEN" and "USE NO OIL" (or a suitable symbol) prominently displayed on the dial.

**A.4.19** Stainless steel filters shall not be used in oxygen service unless certified to be suitable for the given pressure and flows. Only filter materials with a high auto-ignition temperature shall be used. Examples are copper, copper alloys and copper-nickel alloys. Filters in oxygen service shall be tested for resistance to ignition, and certified suitable for service by the original equipment manufacturer.

**A.4.20** Before the oxygen flow rate in a ferrous pipe is increased, it shall be verified with the designer that the safe velocities are not exceeded in any part of the system.

**A.4.21** For oxygen equipment operating above 2,4 MPa, due consideration shall be given to personnel protection.

## A.5 Safety

**A.5.1** Oxygen pipelines should be separated from pipework containing flammable products and from sources of heat or ignition to avoid the possibility of combustion occurring. Separation distances will vary depending on the degree of precaution taken for example ventilation, sleeves and separation barriers.

**A.5.2** Oxygen pipework shall be separated by at least 150 mm from electrical services.

**A.5.3** Warning notices indicating "OXYGEN", "NO SMOKING", "NO IGNITION SOURCES", "USE NO OIL" (or suitable symbolic signs) shall be displayed.

**A.5.4** Enclosed spaces into which oxygen can leak into, shall be ventilated such that a dangerous enrichment of air cannot occur.

**A.5.5** Where oxygen enrichment can occur, any work involving fire, flames or open ignition sources (such as welding, cutting, heating, soldering) shall only be carried out under a Permit to Work System.

**A.5.6** The safe oxygen limit is 19, 5 % to 23,5 % by volume.

# Annex B
(normative)

# Nitrogen

## B.1 General

This annex defines the properties and requirements for nitrogen systems.

## B.2 General data

| | |
|---|---|
| Chemical symbol | $N_2$ |
| Flammability: | Non-flammable |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive |
| Density: | Ambient gas: Slightly lighter than air<br>Cold vapour: Much heavier than air |
| Colour: | Gas: Colourless<br>Cold vapour: May form a white mist or fog cloud<br>Liquid: Colourless |
| Odour: | None |
| Taste | None |
| Liquid boiling point: | –196 °C at 101,3 kPa - absolute |
| Liquid to gas ratio: | 1:691 |

## B.3 Recommended materials

### B.3.1 Piping

All commonly used materials are suitable based on the temperature and pressure of the service conditions.

### B.3.2 Jointing

All commonly used materials are suitable. Jointing and gasket materials shall be suitable for the service conditions. Soft solder shall not be used as a jointing mechanism.

### B.3.3 Valves and other components

All commonly-used materials are suitable provided they suit the service conditions.

## B.4 Special conditions

None.

## B.5 Safety

**B.5.1** Although nitrogen is non-toxic, nitrogen-enriched atmospheres can cause asphyxiation through the depletion of oxygen.

**B.5.2** Cold nitrogen vapour may accumulate in low lying areas.

**B.5.3** Warning notices shall be clearly displayed in nitrogen storage areas with the following, "Nitrogen", "Inert Gas", "Asphyxiation Hazard" and "No Unauthorised Entry". Symbolic signage in accordance with SANS 1186-1 may be used to convey the same warnings.

# Annex C
(normative)

# Argon

## C.1 General

This annex specifies the properties and requirements for argon systems.

## C.2 General data

| | |
|---|---|
| Chemical symbol: | Ar |
| Flammability: | Non-flammable |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive |
| Density: | Ambient gas: Heavier than air<br>Cold vapour: Much heavier than air |
| Colour: | Gas: Colourless<br>Cold vapour: May form a white mist or fog cloud<br>Liquid: Colourless |
| Odour: | None |
| Taste: | None |
| Liquid boiling point: | –185 °C at 101,3 kPa - absolute |
| Liquid to gas ratio | 1:835 |

## C.3 Recommended materials

### C.3.1 Piping

All commonly used materials are suitable based on the temperature and pressure of the service conditions.

### C.3.2 Jointing

All commonly used materials are suitable. Jointing and gasket materials shall be suitable for the service conditions. Soft solder shall not be used as a jointing mechanism.

### C.3.3 Valves and other components

All commonly-used materials are suitable provided they suit the service conditions.

## C.4 Special conditions

None

## C.5 Safety

**C.5.1** Although argon is non-toxic, argon-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**C.5.2** Argon is considerably heavier than air and will accumulate in low-lying or areas of poor ventilation. This fact will influence the gas storage location and ventilation requirements.

**C.5.3** Warning notices shall be clearly displayed in argon storage areas with the following, "Argon", "Inert Gas", "Asphyxiation Hazard" and "No Unauthorised Entry". Symbolic signage in accordance with SANS 1186-1 may be used to convey the same warnings.

# Annex D
(normative)

# Helium

## D.1 General

This annex specifies the properties and requirements for helium systems.

## D.2 General data

| | |
|---|---|
| Chemical symbol: | He |
| Flammability: | Non-flammable |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive |
| Density: | Ambient gas: Much lighter than air<br>Cold vapour: Heavier than air |
| Colour: | Gas: Colourless<br>Cold vapour: May form a white mist or fog cloud<br>Liquid: Colourless |
| Odour: | None |
| Taste: | None |
| Liquid boiling point | –269 °C at 101,3 kPa - absolute |
| Liquid to gas ratio | 1:748 |

## D.3 Recommended materials

### D.3.1 Piping

**D.3.1.1** All commonly used materials are suitable based on the temperature and pressure of the service conditions.

**D.3.1.2** Permeability of materials with helium should be checked with the manufacturer.

**D.3.1.3** Cast iron pipes and fittings shall not be used due to the permeance of helium.

### D.3.2 Jointing

**D.3.2.1** All commonly used materials are suitable. Jointing and gasket materials shall be suitable for the service conditions.

**D.3.2.2** The use of welded or brazed joints is recommended wherever possible.

**D.3.2.3** Where breakable joints (such as threaded, flanged) are considered necessary, these should be kept to a minimum since they are a potential source of leakage. Particular care shall be taken in the use of such connections, owing to the permeance of helium at all pressures.

**D.3.2.4** Soft solder shall not be used as a jointing mechanism.

### D.3.3 Valves and other components

**D.3.3.1** All commonly-used materials are suitable with the exception of cast iron or castings due to the permeance of helium.

**D.3.3.2** The suitability of valves and fittings in the service shall be checked with the OEM for permeability with helium.

## D.4 Special conditions

Helium is an extremely penetrative gas which can leak through joints which have been proved leak tight with nitrogen. Consequently more stringent jointing techniques such as back-brazing of screwed joints may be necessary.

## D.5 Safety

**D.5.1** Although helium is non-toxic, a helium-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**D.5.2** Helium is an extremely light gas which will readily collect at high level. Adequate high level ventilation is therefore necessary.

**D.5.3** Warning notices shall be clearly displayed in helium storage areas with the following, "Helium", "Inert Gas", "Asphyxiation Hazard" and "No Unauthorised Entry". Symbolic signage in accordance with SANS 1186-1 may be used to convey the same warnings.

# Annex E
(normative)

# Hydrogen

## E.1 General

This annex specifies the properties and requirements for hydrogen systems.

## E.2 General data

| | |
|---|---|
| Chemical Symbol: | $H_2$ |
| Flammability: | Flammable (4 % to 75% volume in air) |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive |
| Density: | Ambient gas: Much lighter than air<br>Cold vapour: Heavier than air |
| Colour: | Gas: Colourless<br>Cold vapour: May form a white mist or fog cloud<br>Liquid: Colourless |
| Odour: | None |
| Taste: | None |
| Liquid boiling point: | –259 °C at 101,3 kPa - absolute |
| Liquid to gas ratio | 1:844 |
| NOTE For further information on hydrogen see EIGA IG C121. | |

## E.3 Recommended materials

### E.3.1 Piping

**E.3.1.1** All commonly used materials are suitable based on the temperature and pressure of the service conditions.

**E.3.1.2** Permeability of materials with hydrogen should be checked with the manufacturer.

**E.3.1.3** Cast iron pipes and fittings shall not be used due to the permeance of hydrogen.

**E.3.1.4** Under certain conditions, some high tensile ferrous materials (steels and stainless steels) are susceptible to hydrogen embrittlement. Due consideration shall be given to this when ferrous materials are being selected for hydrogen service.

**E.3.1.5** Seamed pipe shall not be used due to possibility of hydrogen embrittlement.

**E.3.1.6** Titanium is particularly susceptible to hydrogen embrittlement and shall not be used in hydrogen service.

**E.3.1.7** Plastic pipes may be used within the limitations given annex J.

### E.3.2 Jointing

**E.3.2.1** All commonly used materials are suitable. Jointing and gasket materials shall be certified suitable for the service conditions.

**E.3.2.2** The use of welded or brazed joints is recommended wherever possible.

**E.3.2.3** Where breakable joints (threaded, flanged, etc.) are considered necessary, these should be kept to a minimum since they are a potential source of leakage. Particular care shall be taken in the use of such connections, owing to the permeance of hydrogen at all pressures.

**E.3.2.4** Soft solder shall not be used as a jointing mechanism.

### E.3.3 Valves and other components

**E.3.3.1** All commonly-used materials are suitable with the exception of cast iron or castings due to the permeance of hydrogen.

**E.3.3.2** The suitability of valves and fittings in the service shall be checked with the OEM for permeability with hydrogen.

## E.4 Special conditions

**E.4.1** Hydrogen is an extremely penetrative gas which can leak through joints which have been proved leak tight with nitrogen, consequently more stringent jointing techniques such as back-brazing of screwed joints may be necessary.

**E.4.2** Although most commonly used materials are suitable with hydrogen, the problem of embrittlement under cyclic conditions with steel shall be considered especially at elevated temperatures and pressures.

**E.4.3** The use of bursting discs is not recommended on hydrogen systems.

**E.4.4** Hydrogen systems should be leak tested using helium.

## E.5 Safety

**E.5.1** Hydrogen is extremely flammable and requires very little energy to ignite. Hence, vent points may self-ignite. Hydrogen vent lines (including those on pressure relief valves) shall terminate in a safe area at high level where gas cannot accumulate to form a hazard or create a hazard when ignited.

**E.5.2** Hydrogen may spontaneously ignite in the event of a leak or in the event of a relief device opening. Hydrogen flames are almost invisible in daylight and produce low radiant heat. Caution shall be taken when approaching a suspected hydrogen fire. Adequate risk mitigations shall be implemented where there is a high risk of hydrogen fires.

**E.5.3** Hydrogen is an extremely light gas which will readily collect at high levels. Adequate high level ventilation is necessary to prevent accumulation of gas which could form a potentially explosive atmosphere (a continuous ridge vent is recommended).

**E.5.4** Although hydrogen is non-toxic, a hydrogen-enriched atmosphere can cause asphyxiation through the depletion of oxygen.

**E.5.5** Areas around hydrogen installations or applications shall be zoned in accordance with SANS 10108. Electrical equipment and circuits shall be certified accordingly and selected, installed and maintained in accordance with the relevant national legislation (see foreword).

**E.5.6** Pipework shall have a minimum separation distance of 50 mm from electrical services.

**E.5.7** Pipework should be segregated from other pipework carrying oxidizing gases.

**E.5.8** Pipework shall be purged out of service with inert gas until the residual hydrogen concentration is below 1 % by volume and purged into service with an inert gas until all residual oxygen is removed.

**E.5.9** Earth all lines and equipment where there is the possibility of electro-static discharge. Electrical continuity shall be maintained across the entire system.

**E.5.10** Each outlet point of the system shall terminate in a left hand thread.

**E.5.11** Separation distances for hydrogen installations shall take into consideration vertical distances.

**E.5.12** Warning notices "Hydrogen", "Flammable Gas", "No smoking", "No Unauthorised Entry" and "No Ignition Sources" shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with SANS 1186-1.

**E.5.13** Fire-fighting equipment shall be readily available and normally be done by the relevant national body (see foreword).

# Annex F
(normative)

# Methane

## F.1 General

This annex specifies the properties and requirements for methane systems.

## F.2 General data

| | |
|---|---|
| Chemical symbol: | $CH_4$ |
| Flammability: | Flammable (5 % to 15 % volume in air) |
| Toxicity: | Non-toxic |
| Corrosive: | Non-corrosive |
| Density: | Ambient gas: Much lighter than air<br>Cold vapour: Heavier than air |
| Colour: | Gas: Colourless<br>Cold vapour: May form a white mist or fog cloud |
| Odour: | Sweet and Oily |
| Taste: | None |
| Liquid boiling point: | –161 °C at 101,3 kPa - absolute |
| Liquid to gas ratio: | 1:630 |

## F.3 Recommended materials

### F.3.1 Piping

**F.3.1.1** All commonly used materials are suitable based on the temperature and pressure of the service conditions.

**F.3.1.2** The use of copper and copper alloys (with a copper content above 70 %) is not recommended.

**F.3.1.3** Plastic pipes may be used but within the limitations as specified in annex J .

### F.3.2 Jointing

**F.3.2.1** All commonly used materials are suitable.

**F.3.2.2** Gasket materials shall be certified suitable for the service conditions.

**F.3.2.3** Soft solder shall not be used as a jointing mechanism.

### F.3.3 Valves and other components

All commonly-used materials are suitable with the exception of copper and copper alloys with a copper content above 70 %.

## F.4 Special conditions

**F.4.1** Silicon, EPDM, IRR and nitrile rubber elastomers are not permitted for methane service.

**F.4.2** Methane decomposes into acetylene, ethylene and hydrogen. Due to material incompatibility with acetylene, the use of copper or copper alloys with a copper content greater than 70 % is not recommended.

## F.5 Safety

**F.5.1** Methane is extremely flammable. Hence, vent points may self-ignite. Methane vent lines (including those on pressure relief valves) shall terminate in a safe area at high level where gas cannot accumulate to form a hazard or create a hazard when ignited.

**F.5.2** Ventilation shall be provided at high levels to prevent accumulation of gas which could form a potentially explosive atmosphere (a continuous ridge vent is recommended).

**F.5.3** Although methane is non-toxic, methane-enriched atmospheres can cause asphyxiation through the depletion of oxygen.

**F.5.4** Areas around methane installations or applications shall be zoned in accordance with SANS 10108. Electrical equipment and circuits shall be certified accordingly and selected, installed and maintained in accordance with the relevant national legislation (see foreword).

**F.5.5** Pipework shall be purged out of service with inert gas until the residual is below 1 % by volume and purged into service using an inert gas until all traces of oxygen are removed.

**F.5.6** Earth all lines and equipment where there is the possibility of electro-static discharge. Electrical continuity shall be maintained across the entire system.

**F.5.7** Each outlet point of the system shall terminate in a left hand thread.

**F.5.8** Pipework shall have a separation distance of 50 mm from electrical services.

**F.5.9** Pipework should be segregated from other pipework carrying oxidizing gases.

**F.5.10** Separation distances for methane installations shall take into consideration vertical distances.

**F.5.11** Warning notices "Methane", "Flammable Gas", "No Smoking", "No Unauthorised Entry" and "No Ignition Sources" shall be displayed. Where the notice uses a pictorial symbol, then this shall be in accordance with SANS 1186-1.

**F.5.12** Fire-fighting equipment shall be readily available and normally be done by the relevant national body (see foreword).

# Annex G
(normative)

# Carbon dioxide

## G.1 General

This annex specifies the properties and requirements for carbon dioxide systems.

## G.2 General data

| | |
|---|---|
| Chemical symbol: | $CO_2$ |
| Flammability: | Non-flammable |
| Toxicity: | Slightly toxic |
| Corrosive: | Non-corrosive (in absence of moisture) |
| Density: | Ambient gas: Heavier than air<br>Cold vapour: Heavier than air |
| Colour: | Gas: Colourless<br>Cold Vapour: May form a white mist or fog cloud<br>Liquid: Colourless |
| Odour: | Slight pungent odour in high concentrations |
| Taste: | None |
| Liquid sublimation point: | –78 °C at 101,3 kPa - absolute |
| Liquid to gas ratio: | 1:535 |

## G.3 Recommended materials

### G.3.1 Piping

**G.3.1.1** All commonly used materials are suitable based on the temperature and pressure of the service conditions.

**G.3.1.2** Plastic pipes may be used but within the limitations as specified in annex J.

### G.3.2 Jointing

**G.3.2.1** Glass filled PTFE and compressed fibre are recommended.

**G.3.2.2** Elastomers (with the exception of Buna N - Nitrile rubber) will experience swelling when used in liquid carbon dioxide service. In liquid carbon dioxide, glass filled PTFE and nylon is recommended.

**G.3.2.3** Soft solder shall not be used as a jointing mechanism.

### G.3.3 Valves and other components

All commonly-used materials are suitable.

## G.4 Special conditions

**G.4.1** In the presence of moisture, carbonic acid is formed which is corrosive.

**G.4.2** Systems should be purged of moisture using a dry inert gas before being put into service.

## G.5 Safety

**G.5.1** Although carbon dioxide is usually considered to be non-toxic, it does have a long-term (8 h) occupational exposure limit (OEL) of a volume fraction of 0,5% (5 000 ppm) and a short term (15 min) OEL of a volume fraction of 1,5 % (15 000 ppm). Respiration is affected, breathing becomes laboured and mild narcotic effects may be experienced.

**G.5.2** At high concentrations of carbon dioxide may result in paralysis of the respiratory system resulting in the inability to breath.

**G.5.3** Carbon dioxide can cause asphyxiation through depletion of oxygen.

**G.5.4** Carbon dioxide is considerably heavier than air and will accumulate in low-lying or areas of poor ventilation. This fact will influence the gas storage location and ventilation requirements.

**G.5.5** Piping, valves and fittings for use with liquid carbon dioxide require low temperature properties and impact tested materials. A relief valve shall be interposed between any two stop valves where liquid carbon dioxide may be trapped

**G.5.6** High tensile brass is not a recommended material, due to the possibility of stress corrosion cracking.

**G.5.7** Discharge of liquid carbon dioxide can generate static electricity and it should be avoided in or near flammable gas mixtures.

**G.5.8** Low temperatures injuries may occur upon exposure with venting gas, liquid or ice.

**G.5.9** The rapid release of carbon dioxide may cause carbon dioxide solidification which may cause blockages within the system.

**G.5.10** Warning notices shall be clearly displayed in carbon dioxide storage areas with the following, "Carbon dioxide", "Inert gas", "Asphyxiation hazard" and "No unauthorised entry". Symbolic signage in accordance with SANS 1186-1 may be used to convey the same warnings.

# Annex H
(normative)

## Nitrous oxide

**H.1** This annex specifies defines the properties and requirements for nitrous oxide systems.

**H.2** Nitrous oxide systems shall be suitable for oxygen service (see annex A).

## Annex I
(normative)

## Mixed gases

**I.1** This annex specifies the requirements of systems for mixed gases.

**I.2** Pipeline design shall take into consideration the safety issues associated with the gases to be used.

**I.3** When the safety issues have been identified, then, categorize what materials can safely be specified for piping, hoses and other equipment used in the supply and distribution system and design the system on this basis, taking into account also the operating and system design pressure requirements.

**I.4** Establish safe procedures for installation, operation and maintenance of the system and agree emergency procedures to cover any potentially hazardous incidents which may occur.

**I.5** Consideration should be given to withdrawal rates from the system. This will affect sizing of the manifold and piping and, in the case of liquefied gases in cylinders, the number of cylinders required. The possibility of freezing up of pressure regulators should also be considered (for example methane and methane mixtures).

**I.6** Identify if, under certain conditions, condensable products can be obtained in the system from the mixture, and establish any precautions or modifications which may be required, for example drainage points, trace heating.

**I.7** For flammable mixtures, ensure that cylinders and manifolds, equipment and pipework are adequately and continuously earthed.

**I.8** A relief valve shall be interposed between any two stop valves where liquid may be trapped.

**I.9** Consideration shall be given to the withdrawal to ensure the mixed gas is delivered at the usage point in the correct ratio.

**I.10** Ventilation shall be provided at high and low levels as necessary to prevent enrichment of the normal atmosphere.

# Annex J
(normative)

## Plastic pipes

**J.1** This annex specifies the requirements for the use of plastic pipes in gas systems.

**J.2** Plastic piping may be used in inert gas providing that the following criteria are met:

a) There shall be a minimum ratio between the burst and the safe working pressure of 4:1.

b) Design temperature shall be within the range –20 °C to +50 °C. Note that most plastics become embrittled at low temperatures and should not therefore be used where temperatures below –20 °C are likely to be encountered. The maximum working pressures of plastics reduce as the operating temperature increases, therefore care shall be taken in terms of the operating environment in which materials of this nature are being considered for use, in order to ensure that the working pressure does not exceed the system design pressure at the operating temperature.

c) Where plastic piping is proposed to be used, due attention shall be paid to the coefficient of expansion of the material when designing such systems in order to make allowance for this factor.

d) Most plastics degrade in the presence of UV light and this should also be taken into consideration at the design stage, bearing in mind the operating pressures, temperatures and environment in which the system is to operate, in order to ensure that a suitable design life is specified.

e) Plastic piping is potentially more easily damaged than piping manufactured from steel or copper. Care shall therefore be taken to ensure that this factor is also taken into account at the installation stage.

f) The use of plastic piping shall be limited to a maximum outside diameter of 15 mm.

**J.3** Where plastic piping is to be used for flammable and oxidant gases, the following criteria shall be met:

a) All requirements stated in J.2.

b) Plastic piping can only be used after a detailed evaluation and risk assessment has been carried out. Specific consideration shall be given to material compatibility, operating pressures, operating temperatures and flows.

**J.4** Where flexible plastic piping is used, sufficient supports should be used to prevent the piping from sagging between supports, supporting on cable trays rather than on standard support systems may be a preferable alternative.

**J.5** Taking into account the requirements in J2, J3 and J4 and the design of the piping currently available, plastic piping should only be used for applications where the system pressure is prevented from exceeding the safe operating limits specified by the manufacturer by the use of suitable safety pressure relief devices, for inert gas service, in environments where the possibility of mechanical damage is minimal.

**J.6** It is also important to ensure that the ultimate user of the system recognises that the piping is to a specific design and that any replacement that is fitted shall comply with the original specification.

# Annex K
(informative)

## Gas concentration calculation for manifold rooms

**K.1** This annex specifies the calculations used to determine gas concentrations in manifold rooms.

**K.2** The following process is recommended to determine if a manifold gas supply installation can be sited inside a room:

a) Determine the room volume : $V_r$ = ………………………………… in $m^3$

b) Determine the potential gas release inside the room.

1) For compressed gas cylinders manifolded together

Number of cylinder manifolded together: $n$ = …………………..

Volume of a cylinder: $V_{cyl}$ = …………………. in litres

Maximum pressure for a cylinder: $P_{cyl}$ = …………………. in bar

The worst case potential gas release is determined by:

$$V_g = \frac{n \times V_{cyl} \times P_{cyl}}{1000}$$ …………………….. in $m^3$

2) For liquid gas containers manifolded together

Number of containers manifolded together: $n$ = …………………..

Volume of a container : $V_{con}$ = …………………. in litres

3) The expansion ratio from liquid being converted into gas based on the gas type: $E_{ratio}$ = …………………

| Product | Expansion ratio |
|---|---|
| Nitrogen | 691 |
| Oxygen | 854 |
| Argon | 835 |
| Carbon Dioxide | 535 |
| Helium | 748 |
| Nitrous Oxide | 665 |

The worst case potential gas released is determined by:

$$Vg = \frac{n \times V_{con} \times E_{ratio}}{1\,000}$$

NOTE 1 If a number of **inert** gas systems are sited inside the same room, the system with the highest Vg should be used in the calculations going forward.

NOTE 2 If oxygen is sited inside the same room with other systems, the following calculations should also be done to determine oxygen enrichment probability.

NOTE 3 If any of the gas systems are flammable or toxic, the following calculation should be done for each of these gases to determine flammability/toxicity risk

c) The concentration of the room environment in the event of a release can be calculated as follows:

1) For rooms without a ventilation system

i) For **inert gases** released into the room:

$V_o$ = 0,21 ($V_r$ - $V_g$)

= 0,21 × (………. - ………….)

= …………… in $m^3$

The concentration of oxygen is then:

$$Conc_{O2} = 100 \times \frac{V_o}{V_r}$$

= 100 × ………….. / ……………

= ………….. in %

The oxygen level shall be between 19,5 % to 23,5% to be safe.

ii) For **oxygen** released into the room:

$V_o$ = 0,21 ($V_r$ - $V_g$) + $V_g$

= 0,21 × (………. - ………….) + …………

= …………… in $m^3$

NOTE 1 For $V_r$ see K(a).

NOTE 2 For $V_g$ see K(b).

The concentration of oxygen is then:

$$Conc_{O2} = 100 \times \frac{V_o}{V_r}$$

= 100 × ………….. / ……………

= ………….. in %

The oxygen level shall be between 19,5 % to 23,5% to be safe.

iii) For the concentration of a **flammable or toxic** gas:

$$Conc_{Tox/Flam} = \frac{100 \times Vg_{(flam/tox)}}{V_r}$$

= 100 × ………….. / ……………

= ………….. in %

The flammable/toxic gas level shall be outside of the recommended explosive/toxic limits for it to be deemed safe.

2) For ventilated rooms:

The rate of ventilation: $N$ = ………..in number of air changes per hour

The rate of gas released: $L$ = ……………. in m$^3$/h

Time since gas was release: $t$ = …………….. in hours

$$C_t = 0{,}21 + \left[ \frac{0{,}21n}{\left( \frac{L}{V_r} + n \right)} - 0{,}21 \right] \left[ 1 - e^{-t/m} \right]$$

where: $m = \frac{V_r}{(L + N \times V_r)}$

$C_t$ = …………….. × 100 = ………… in %

If the gas release is over a long time period then:

$$C_\infty = \frac{21N \times V_r}{L + N \times V_r}$$

= ……………….. in %

The oxygen level shall be between 19,5 % to 23,5% to be safe.

## K.3 Example calculations

### K.3.1 Example calculation 1

One compressed gas nitrogen cylinder 50 L, 20 MPa cylinder is used in a workplace with a room volume of 75 m$^3$.

1) Determine the room volume: $Vr$ = ………………75…………… in m$^3$

2) Determine the potential gas release inside the room.

For compressed gas cylinders manifolded together

Number of cylinder manifolded together: $n$ = …1………………..

Volume of a cylinder : $V$cyl = …50………… in litres

Maximum pressure for a cylinder: $P$cyl = …200..………. in bar

The worst case potential gas release is determined by:

$$Vg = \frac{n \times V_{cyl} \times P_{cyl}}{1\,000} = \text{.........10......} \text{ in } m^3$$

3) For rooms without a ventilation system, the amount of oxygen remaining in the room after release is for **inert gases** and is as follows:

$$Vo = 0{,}21\ (Vr - Vg)$$

$$= 0{,}21 \times (\text{...75.... – ...10.......})$$

$$= 13{,}65\text{......} \text{ in } m^3$$

4) The concentration of oxygen is then:

$$\text{ConcO}^2 = 100 \times \frac{V_o}{V_r}$$

$$= 100 \times \frac{13{,}65}{75}\ \text{...}$$

$$= \text{...18,2.....} \text{ in } \%$$

This oxygen concentration is the minimum workplace concentration for normal working requirement. However, the instantaneous release of the whole contents of a compressed gas cylinder is an almost inconceivable event, and not foreseeable as part of normal working. Thus specific preventative measures are unlikely to be required in this case.

### K.3.2 Example calculation 2

One liquid nitrogen 50 L tank being used in a workplace with a free air volume of 75 $m^3$

1) Determine the room volume: *Vr* = ………………75…………… in m3

2) Determine the potential gas release inside the room.

Number of container manifolded together : *n* = 1

Volume of a container : *V*con = 50…….in liters

The expansion ratio from liquid being converted into gas based on the gas type:

*E*ratio = 683

The worst case potential gas released is determined by:

$$Vg = \frac{n \times V_{con} \times E_{ratio}}{1\,000} = 34{,}15 \text{ in } m^3$$

3) For rooms without a ventilation system, the amount of oxygen remaining in the room after release is for **inert gases** and is as follows:

$Vo$ = 0,21 ($Vr$ – $Vg$)

= 0,21 × (…75…. – …34.15…….)

= …8,58…… in $m^3$

4) The concentration of oxygen is then:

$$\text{ConcO2} = 100 \times \frac{V_o}{V_r}$$

$$= 100 \times \frac{8,75}{75}$$

= 100 × …8,58.. / …75

= …11,44….. in %

This oxygen concentration is clearly below the minimum requirement and would represent an immediate threat to life. The instantaneous loss of the full contents of a 50 L liquid tank is a very unlikely event, and the probability that this could occur needs to be assessed for the specific activity being undertaken. Preventative measures will be necessary where such a loss of contents is reasonably foreseeable.

### K.3.3 Example calculation 3

One 5,1 kg carbon dioxide cylinder being used in a workplace with a free air volume of 75 $m^3$

1) Determine the room volume: *V*r = ………………75…………… in $m^3$

2) Determine the potential gas release inside the room.

Number of container manifolded together : *n* = 1

Volume of a container : *V*con = 6,57 L

(since density of liquid $CO_2$ is 0,776 kg/L, the volume can be assumed as 5,1/0,776)

The expansion ratio from liquid being converted into gas based on the gas type:

*E*ratio = 543

The worst case potential gas released is determined by:

$$Vg = \frac{n \times V_{con} \times E_{ratio}}{1\,000} = 3{,}57 \text{ in } m^3$$

3) For rooms without a ventilation system, the amount of oxygen remaining in the room after release is for **inert gases** and is determined as follows:

$$Vo = 0{,}21\ (Vr - Vg)$$

$$= 0{,}21 \times (…75…. – …3{,}57…….)$$

$$= …15…… \text{ in } m^3$$

4) The concentration of oxygen is then:

$$ConcO_2 = 100 \times \frac{V_o}{V_r}$$

$$= 100 \times \frac{15}{75}$$

$$= …20….. \text{ in } \%$$

5) As $CO_2$ is slightly toxic for the concentration of a flammable or toxic gas:

$$Conc_{Tox/Flam} = \frac{100 \times Vg_{flam/tox}}{V_r}$$

$$= 100 \times \frac{3{,}57}{75}$$

$$= …4{,}8.. \text{ in } \%$$

This oxygen concentration is above the minimum requirement. However carbon dioxide is mildly toxic and therefore the relevant national legislation (see foreword) has defined an occupational exposure limit of 0,5 % averaged over 8 h, with a maximum exposure of 1,5 % for short periods of 15 min. The volume of carbon dioxide from this 5,1 kg cylinder could produce a concentration of 4,8 % in case of complete loss via, for example, a bursting disc failure. This would produce a dangerous atmosphere and preventive measures are necessary.

### K.3.4 Example calculation 4

An inert gas is being used in a work place with a free air volume of 18 m$^3$, the gas flow rate is 1,1 m$^3$/h, the air changes are 0,4 per h and the time taken to complete the job is 2 h.

To establish the effect of this activity on the workplace atmosphere after 2 h the following formula is used:

1) Determine the room volume : *V*r = ………18………… in m$^3$

2) For ventilated rooms

The rate of ventilation: *N* = …0.4… in number of air changes

The rate of gas released: *L* = …1.1……. in m$^3$/h

Time since gas was release: *t* = …2…….. in hours

$$C_t = 0{,}21 + \left[ \frac{0{,}21n}{\left( \frac{L}{V_r} + n \right)} - 0{,}21 \right] \left[ 1 - e^{-t/m} \right]$$

where: $m = \frac{V_r}{(L + N \times V_r)} = 2{,}17$

*C*t = …0.193….. × 100 = …19,3…. in %

The oxygen concentration in the workplace has dropped to 19,3 %, which is below the minimum requirement (19,5 %), therefore preventative measures will need to be taken.

### K.3.5 Example calculation 5

A 50 L, 20 MPa (200 bar) cylinder of hydrogen in a room of internal volume 75 m$^3$. The volume of gas contained in the cylinder is 8,796 m$^3$, measured at 101,3 kPa (1,013 bar) and 15 °C.

1) Determine the room volume: *V*r = ………………75…………… in m$^3$

2) Determine the potential gas release inside the room.

| | |
|---|---|
| Number of container manifolded together: | *n* = 1 |
| Volume of a cylinder: | *V*cyl = …50………… in liters |
| Maximum pressure for a cylinder: | *P*cyl = …200..………. in bar |

The worst case potential gas release is determined by:

$$Vg = \frac{n \times V_{cyl} \times P_{cyl}}{1\,000} = \text{.........10......} \text{ in m}^3$$

3) For rooms without a ventilation system, the amount of oxygen remaining in the room after release is for **inert gases** and is follows:

$$Vo = 0{,}21\ (Vr - Vg)$$

$$= 0{,}21 \times (\text{...75....} - \text{...10.......})$$

$$= \text{...13,65......} \text{ in m}^3$$

4) The concentration of oxygen is then:

$$ConcO_2 = 100 \times \frac{V_o}{V_r}$$

$$= 100 \times \text{...13,65..} / \text{...75}$$

$$= \text{...18,2.....} \text{ in \%}$$

5) As $H_2$ is flammable, for the concentration of a flammable or toxic gas:

$$Conc_{Tox/Flam} = \frac{100 \times Vg_{flam/tox}}{V_r}$$

$$= 100 \times 10.. / 75$$

$$= \text{...13,3..} \text{ in \%}$$

As in example calculation 1, the instantaneous release of the complete contents of the cylinder is not normally a reasonably foreseeable event, however the result is over 13 times the suggested maximum acceptable gas concentration (25 % of LEL, which is for hydrogen in air 4 %, giving a maximum allowable concentration of 1 %). There is therefore sufficient gas to cause a dangerous situation, and a detailed risk assessment will be needed to decide how to make the situation acceptable, for example by defining the room as a zoned area, requiring that all sources of ignition and electrical equipment be designed accordingly.

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