INTERNATIONAL STANDARD

ISO 22252

First edition
2020-01

Manned submersibles — Breathing air supply and CO2 adsorption systems — Performance requirements and recommendations

Reference number
ISO 22252:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 13, *Marine technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Manned submersibles — Breathing air supply and CO2 adsorption systems — Performance requirements and recommendations

1 Scope

This document specifies performance requirements and gives recommendations for the design of breathing air supply and CO_2 absorption systems of manned submersibles, capable of maintaining suitable life support conditions in the manned compartments.

It is applicable to manned submersibles where the internal pressure of the manned compartment is normally maintained at or near to one atmosphere.

It is not applicable to submersibles where the occupants endure pressures higher than one atmosphere (such as in diving bells, for example).

It is not applicable to submersibles designed to carry passengers or divers in a separate compartment capable of being pressurised to higher than one atmosphere inside the pressure hull (such as in submarine rescue compartments, for example).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
diving bell
manned non-self-propelled submersible tethered unit consisting of at least one chamber internally pressurized in order to allow a diver to be transported to and from an underwater site

3.2
manned submersible
craft capable of carrying personnel and/or *passengers* (3.6) while operating underwater, submerging, surfacing and remaining afloat with the internal pressure of the *manned compartment* (3.4) normally maintained at or near to one atmosphere

3.3
pressure hull
hull of a submersible that maintains structural integrity while under differential pressure

3.4
manned compartment
compartment of the *pressure hull* (3.3) in which people are carried, generally maintained at a pressure of one atmosphere

3.5
passenger submersible
submersible carrying *passengers* (3.6) that primarily operates underwater and relies on surface support, such as a surface ship or shore-based facilities, for monitoring and for one or more of the following: recharging power supply, recharging high pressure air and recharging life-support

3.6
passenger
person other than the pilot and the members of the crew or other persons employed in any capacity on board a *passenger submersible* (3.5) craft on the business of the craft

3.7
breathing air supply system
equipment providing breathing air to the *manned compartment(s)* (3.4) while the submersible is surfaced or submerged

3.8
reserve breathing air supply system
breathing air supply equipment specifically designated as the 'reserve' component, that is not normally used during planned dives unless some unforeseen emergency circumstance occurs

3.9
emergency breathing air supply system
equipment providing an independent emergency air supply for use in case of fire, smoke or other toxic contaminants in manned compartment(s) or failure of the normal and the *reserve breathing air supply system* (3.8)

3.10
CO_2 absorption system
equipment providing CO_2 absorption while the submersible is surfaced or submerged

3.11
LiOH
lithium hydroxide
highly alkaline inorganic compound that can absorb CO_2 in the air

4 General requirements and recommendations

4.1 The breathing air supply system shall be designed with redundancies to avoid loss of breathing air supply due to a single failure in the system.

4.2 The CO_2 absorption system shall be designed with redundancies to avoid loss of CO_2 removal capability due to a single failure in the system.

4.3 The breathing air supply and CO_2 absorption systems should be designed so that as far as reasonably practicable, incorrect operation of the equipment by trained personnel is not possible.

4.4 The breathing air supply and CO_2 absorption systems shall be fit for purpose to operate safely in the specified operating parameters of the submersible. This shall be as a result of a design specification configured to the required safe operating envelope.

4.5 The electronic equipment and systems associated with breathing air supply and CO_2 absorption systems shall be able to adapt to the electromagnetic environment of the submersible. Anti-electromagnetic interference measures can be considered if necessary, for example, resisting interference from the VHF.

4.6 The appropriate risk analysis should be used in the design of the breathing air supply and CO_2 absorption systems, which can refer to IEC 60812 or equivalent standards.

5 Material requirements and recommendations

5.1 Materials containing beryllium, asbestos and mercury shall not be used in the breathing air supply system and in the CO_2 absorption system.

5.2 The material used in the manufacture of pipework in the breathing air supply system should be suitable for the gas in the pipework.

5.3 The metal materials used in breathing air pipework should be nickel-copper alloy (Monel), 304 or 316 stainless steel, copper, aluminum bronze (except those alloys subject to dealuminification), copper nickel, brass (except those alloys subject to dezincification), or C-69100 copper alloy. Aluminum may only be used when adequate precautions are taken to prevent contact with fluorochlorocarbon lubricants and hydroxide based CO_2 absorbents.

5.4 Other suitable materials may be considered on a case-by-case basis after evaluation of their material specifications.

5.5 The following materials shall not be used for the breathing air supply pipework:

a) carbon steel,

b) cast, ductile and malleable iron piping, tubing and fittings,

c) plating or coatings with cadmium.

5.6 Pipework exposed to seawater shall be manufactured from material resistant to seawater corrosion.

5.7 Soft goods (non-metallic materials such as gaskets, O-rings, valve seats, etc.) used in the breathing air supply pipework shall be compatible with the gas in the pipe.

5.8 If lubricant or sealant is used in breathing system pipework, it shall be compatible with the gas in the pipe. If the gas has an oxygen concentration exceeding 25 %, the lubricant or sealant shall be compatible with oxygen at the maximum system supply pressure and flow rate.

5.9 If PTFE tape type thread sealant is used in threaded joints in the breathing air supply pipework, it shall be demonstrated that all potential hazards associated with the disintegration/shredding of the tape have been addressed.

5.10 Valve parts in the breathing air supply pipework shall meet the material requirements of 5.1 to 5.9.

5.11 The manufacturing materials of the CO_2 absorption system shall be corrosion-resistant and non-toxic, and the materials shall be compatible for use with CO_2 absorbent chemicals.

6 Breathing air supply system requirements and recommendations

6.1 Breathing air management

a) The oxygen concentration in the manned compartment should be kept between 18 % and 23 % by volume.

b) The air purity standard for the breathing air supply should be in accordance with recognized standards, such as ISO 8573-1:2010, CGA G-7.1-2011 or equivalent standards.

6.2 Oxygen supply

The oxygen supply rate in the manned submersible should be not less than 28,3 litres per person per hour measured at one atmosphere with temperature of 20 °C.

6.3 Breathing air supply system design

a) The breathing air supply system should comprise three parts: normal breathing air supply system, reserve breathing air supply system and emergency breathing air supply system.

b) The emergency breathing air supply system shall be independent of the normal breathing air supply system and the reserve breathing air supply system.

c) The reserve breathing air supply system shall provide oxygen at the level needed to meet the anticipated consumption rate of the personnel in the manned compartment when an abnormal operating parameter prevents the submersible from returning to the surface. This system allows time for the submersible's rescue by others.

d) The emergency breathing air supply system provides an independent life support air supply when normal and reserve air supplies are unavailable for whatever reason, or if the manned compartment atmosphere has become contaminated with hazardous pollutants. If open circuit systems are used, the effects of increased compartment pressure should be considered.

e) The emergency breathing air supply system may be a built-in breathing system (BIBS) supplied from breathing gas cylinders, and/or a portable breathing apparatus using its own supply. A face mask connected to the breathing gas supply should be provided for each person.

6.4 Breathing air capacity

a) The submersible's normal breathing air supply should be designed to be sufficient to provide air for the duration of the vessel's design mission safe operating envelope.

b) The capacity of the reserve breathing air supply system should be consistent with the emergency rescue plan and not less than the breathing demand for 72 h.

c) The emergency breathing air supply system should be designed to provide an independent emergency air supply sufficient for 150 % of the time normally required to reach the surface or 1 h, whichever is greater.

6.5 Breathing air cylinder

a) If gas cylinders are used to store the breathing air, they should comply with recognized standards, such as ISO 9809-1:2019, ISO 9809-2:2019, ISO 9809-3:2019, ISO 9809-4:2014, CGA publications or equivalent standards.

b) Oxygen or other gas cylinders shall be limited by designed volume if they are stored inside the pressure hull. Cylinders whose contents, if completely released into the pressure hull, would result in the pressure rising more than 1 atm or oxygen level rising above 23 % by volume, shall not be stored inside the pressure hull.

c) When the cylinders are intended to be stored outside the pressure hull, they should be arranged in at least two banks with separate penetrations entering the pressure hull. The cylinders should be designed for an external pressure differential not less than the rated pressure of the submersible. These penetrations should be positioned such as to minimize the possibility that a single incident would cause failure of all these penetrators.

6.6 Breathing air supply pipework

a) Each independent breathing air supply pipework should be equipped with a supply pressure gauge and a shut-off valve downstream of the supply pressure gauge connection. A block valve, located such that it is capable of being monitored during operation, should be installed between the supply line and the supply pressure gauge to permit isolating the pressure gauge.

b) Pipes used in the breathing air supply pipework should have a burst strength of at least four times the maximum allowable working pressure (MAWP) of the system. The MAWP of pipes should not exceed 34,475 MPa gauge (1 MPa = 145,038 psi).

c) If lubricants and sealants are used in breathing air supply pipework, they should be compatible with the breathing air at the maximum system supply pressure and the maximum flow rate.

d) The breathing air pipework should be secured to prevent movement and easy to maintain.

e) The breathing air supply pipework which can be susceptible to mechanical damage should be adequately protected.

f) Flow control valves should be fitted to pipework to enable smooth control of gas flow.

g) Valves used in the breathing air pipework should be suitable for service with the gas at the system's MAWP. Valves intended for oxygen service shall be suitable for service at the maximum flow rate of oxygen.

h) Valves should comply with a recognized standard and should be permanently marked in accordance with the requirements of the standard.

i) For valves not complying with a recognized standard, they should have a burst strength of at least four times the maximum allowable working pressure (MAWP) of the pipework. They may be accepted on the basis of manufacturer specified pressure and temperature ratings, test data and burst strength ratings. Non-standard valves should be permanently marked with the manufacturer's name or trademark, model/part number as well as their pressure and temperature pressure ratings. As an alternative, this information may be indicated by means of a permanent tag similar to that indicated in standard valves.

j) The primary shut-off valve, or the final shut-off valve where accessible, on a breathing air supply pipework shall be located such that release of the volume contained in the downstream piping does not increase the pressure by more than 1 atm nor raises the oxygen concentration above 23 % by volume.

k) Control valves used in oxygen systems operating at pressures exceeding 861,875 kPa gauge (1 kPa = 0,145 04 psi) should be of the slow-opening type, such as needle valves. Flow control valves shall provide smooth flow transition from full open to full closed.

l) Breathing air supply piping that penetrates the pressure boundary of the manned compartment shall be fitted with a manual shut-off valve mounted directly on the inner side of the pressure boundary. Where this is not practicable, short and strong stub pieces capable of withstanding the anticipated mechanical and pressure loads shall be fitted between the manual shut-off valve and pressure boundary. If this manual shut-off valve is used as the emergency shut-off for the breathing air supply, then it need not follow the requirements under 6.6 k).

m) The atmosphere control system in the manned compartment should ensure that the breathing air is evenly and consistently available. Any risk of 'deadspace' in the manned compartment should be removed or managed effectively by the atmosphere control system.

n) The oxygen supply pipework should be fitted well clear of the hydraulic system so as to minimize risk of fire from any oxygen leaking from the pipework. If unavoidable, adequate measures should be taken to prevent the danger.

o) The oxygen supply piping should be fitted well clear of large electrical equipment such as motors and batteries so as to minimize fire hazards and accelerated ageing of the electrical equipment due to oxygen leakage. If this is unavoidable, then adequate measures should be taken to prevent or mitigate the above hazards.

p) The breathing air supply pipework should be clearly marked so as to indicate its application and the gas carried.

q) Flexible, non-metallic hoses may be used on breathing air supply systems, but should be as short as practicable in length. Such pipework should comply with a design specification standard appropriate to its use and operating safety limitations. This specification should include, but not be limited to, consideration of the following criteria: gas pressure, temperature, environmental protection, incombustibility, corrosion risk, gas permeability and compatibility with oxygen where applicable. The following guidance is provided as recommended minimum required performance criteria.

   1) Hoses should be suitable for use at the maximum flow rate of the gases and the MAWP.

   2) The MAWP of hoses should not exceed 34,475 MPa gauge (1 MPa = 145,038 psi), and the burst strength should be not less than 4 times the MAWP.

   3) Systems, fittings and equipment subject to internal or external pressures or a combination of both should be suitable for this purpose. All piping which may be exposed to the sea pressure should be able to withstand the design depth of the hull.

   4) The hose end fittings should be of a type that forms a complete seal at the ends of the hose, fittings that leave the cut ends of the hose exposed to pressure shall not be used.

   5) The hoses should be installed in such a manner that minimizes kinks, crushing, etc., so as to prevent premature collapsing of the hoses when subject to external pressure.

   6) Hoses should be marked with the manufacturer's name or trademark, model/part number, hose size, as well as their pressure and temperature ratings. This information shall be either permanently printed on the hose or on a permanently attached tag. Tags, when used, should be attached in such a manner that they do not abrade the hose or prevent the hose from bending or expanding due to pressure.

   7) The hose should have the protective covering which can protect the hose from inadvertent mechanical damage.

7 CO_2 absorption system requirements and recommendations

7.1 CO_2 management

a) The CO_2 content of the breathing gas within the manned compartment should be maintained below 0,5 % by volume at 1 atm during the anticipated submerging time and the reserve time.

b) The CO_2 content of the breathing gas within the manned compartment should be maintained below 1 % by volume at 1 atm when the emergency breathing system is used.

7.2 CO_2 absorption system design

The CO_2 absorption system shall be designed for a CO_2 production rate of not less than 0,052 3 kg per hour per person measured at 1 atm and at a temperature of 20 °C. The design calculations should take into account temperature, humidity, absorption efficiency and flow rate.

7.3 CO_2 absorbents

a) The absorbents used should not cause secondary contamination to the environment in the manned compartment.

b) The absorbents should be stored in containers free of moisture.

c) The absorbents should be easily replaced without the need for special tools in the compartment.

d) Solid absorbents should be granular (particle sizes being usually in the 4 to 20 mesh range).

e) If liquid absorbents (for example, LiOH) are used, means should be provided to prevent drippings of absorbent material from dropping onto occupants, structures or equipment. The canisters or panels of liquid absorbents should be replaced as complete units.

f) If liquid absorbents are used, proper heating shall be provided to maintain the temperature of canisters containing other alkaline hydroxides (except LiOH) at or above 15 °C.

g) Solid and liquid based CO_2 absorbent systems which use regenerable reagents can be fitted in submersibles provided there is adequate monitoring of the CO_2 scrubbed gas to ensure it is free of organic matter and moisture. Such systems should be provided with a suitable means of disposing of the CO_2. Solid reagents should be stored in moisture free containers.

h) CO_2 absorption performance should be accurate and adequately presented to the submersible's crew.

7.4 CO_2 absorbents capacity

The storage of CO_2 absorbents should be consistent with the breathing air capacity specified in 6.4.