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Aircraft oxygen systems and equipment —

Part 1: Design and installation

ICS 49.090

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Committees responsible for this British Standard

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British Airways

British Compressed Gases Association

Civil Aviation Authority

Health and Safety Executive

Ministry of Defence

Society of British Aerospace Companies Limited

South Bank University

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Contents

Foreword

This Part of BS 4N 100 has been prepared by Technical Committee ACE/38 and specifies the general design and installation of oxygen systems and equipment for use on aircraft and ground support equipment. It partially supersedes BS 3N 100 which is withdrawn upon publication of all seven parts.

BS 4N 100 consists of the following seven separate parts:

— Part 1: *Design and installation*;

— Part 2: *Tests for the compatibility of materials in the presence of oxygen*;

— Part 3: *Testing of equipment and systems*;

— Part 4: *Guide to the physiological factors*;

— Part 5: *Guide to fire and explosion hazards associated with oxygen*;

— Part 6: *Guidance and recommendations on the selection of materials for use with oxygen*;

— Part 7: *Guide to cleaning, labelling and packaging.*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

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1 Scope

This part of BS 4N 100 specifies the general design requirements for airborne oxygen breathing systems, including oxygen storage and generation equipment and ground support equipment. New tests are specified for compatibility of materials for use in the presence of oxygen. This part also provides some guidance and recommendations on the design and installation of items of equipment for use in oxygen systems.

NOTE The guidance and recommendations contained herein may be used equally well in non-aerospace applications.

In addition, for all equipment for aircraft oxygen systems, conformance to the relevant parts, sections and sub-sections of BS G 100 is specified.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references the latest edition of the publication referred to applies.

BS C 5, *Specification for mating dimensions for liquid oxygen replenishment couplings.*

BS C 20, *Specification for aircraft gaseous oxygen replenishment connection (inch dimensions).*

BS G 100-2-3, *Specification for general requirements for electrical equipment and indicating instruments for aircraft — Environmental conditions.*

BS G 100-2-3-3.3, *Specification for general requirements for electrical equipment and indicating instruments for aircraft — Mould growth.*

BS N 2, *Specification for general requirements for construction and performance of airborne chemical oxygen generators.*

BS N 100-2, *Aircraft oxygen systems and equipment — Tests for the compatibility of materials in the presence of oxygen.*

BS N 100-3, *Aircraft oxygen systems and equipment — Methods of testing equipment and systems.*

BS N 100-5, *Aircraft oxygen systems and equipment — Guide to fire and explosion hazards associated with oxygen.*

BS N 100-6, *Aircraft oxygen systems and equipment — Guidance and recommendations on the selection of materials for use with oxygen.*

BS N 100-7, *Aircraft oxygen systems and equipment — Guide to cleaning, labelling and packaging.*

BS M 23, *Specification for an identification scheme for pipelines.*

3 Pressure ranges

The absolute pressure ranges used in this standard shall be specified as shown in Table 1.

Table 1 — Pressure ranges

Range	Pressure MPa[1)]	Pressure (pounds per square inch) (psi)
Very low	From 0 up to 0.4	From 0 up to 60
Low	From 0.4 up to 1.5	From 60 up to 220
Medium	From 1.5 up to 4.1	From 220 up to 600
High	From 4.1 up to 20.7	From 600 up to 3 000
Very high	Above 20.7	Above 3 000

[1)] 1 MPa = 1 MN/m2 = 145.038 psi = 10 bar.

4 General

4.1 Fixed systems shall be installed so that components and pipelines are as follows:

a) separated from other potentially hazardous systems, for example electrical, hydraulic and fuel systems;

b) located so that accumulation of oxygen will not cause a hazard;

c) clear of moving controls and other mechanisms;

d) bonded to earth.

In addition, fixed systems shall also be installed so that components and pipelines are:

1) routed to minimize the number of joints, the lengths of supply pipes and the number of sharp bends;

2) protected against the ingress of grease and other contaminants;

3) supported and protected against adverse effects of vibration and acceleration.

NOTE Parts of a system subject to medium, high or very high oxygen pressures, located in crew and passenger compartments, shall be either routed or physically protected to prevent accidental damage.

4.2 Thin sections or foils shall not be used except for filters (see clause **7**) or similar features. There shall be no sharp edges or burrs within the oxygen stream.

NOTE Under high velocity oxygen flow conditions, sharp edges, etc. may be ignited by high temperatures being generated.

4.3 Items fitted to or adjacent to personnel shall have no sharp corners, edges or protrusions which could cause personal injury or catch on clothing or equipment.

4.4 Chemical oxygen generators and their installation shall conform to BS N 2.

4.5 Individual components shall be compatible with the rest of the system. Suitability of components shall be ensured during their design, development and qualification test.

NOTE System design should encompass the following criteria:

a) container size, storage pressure, system flow characteristics, the need for a reducing valve and the regulator inlet working pressure range. All these factors are interlinked and have to be considered together to produce the optimum overall storage and supply system;

b) the pressure/flow dynamics of the system, especially with regard to the stability of inspiratory flows. The regulator, low and very low pressure delivery pipelines, mask and the human respiratory system are usually the critical, interacting items;

c) the acoustic characteristics, that is the "breathing noise" produced in any system which includes a mask-mounted microphone. Here the regulator, low and very low pressure pipelines and mask are usually the critical, interacting items;

d) the integration of certain components such as the regulator and associated pipelines, with the seat, the clothing and any personal equipment;

e) condition of handling, storage and use, so that equipment performance is not adversely affected;

f) safety, reliability and maintainability.

4.6 The system shall include emergency oxygen equipment for passengers and crew.

NOTE 1 It is essential that emergency oxygen equipment should be immediately available and in a serviceable condition at all times.

NOTE 2 Physiological considerations are described in detail in BS N 100-4.

4.7 Where blind or intuitive operation of a handwheel or rotary lever is required, the sense of operation shall be such that an upwards or forwards movement of a lever opens or increases the supply. Shut-off valves shall be opened by an anti-clockwise movement of the handwheel or rotary lever and closed by a clockwise movement.

NOTE Shut-off valves should be designed so that when they are operated, the rate of pressure rise within the system does not result in the development, by adiabatic compression, of a temperature high enough to ignite materials in the system.

5 Materials

5.1 Material compatibility in presence of oxygen

5.1.1 *General*

Selection of metallic and non-metallic materials to be used in gaseous oxygen or oxygen rich atmospheres shall conform to BS N 100-6.

5.1.2 *Protective treatment*

Where protective treatment is applied to parts of the system, it shall not affect the ability of the material to conform to BS N 100-2.

5.2 Metallic materials

5.2.1 Adjacent metals shall be electrolytically compatible.

NOTE At extremes of temperature the dimensions and properties of many metals change. Due account of this should be taken, particularly when designing stressed components.

5.2.2 Where relative movement occurs between adjacent parts, as on assembly or during normal use, no loose particles shall be generated.

5.3 Non-metallic materials

NOTE 1 At the temperature of liquid oxygen, most non-metallic materials become brittle. This factor should be borne in mind in the design of low-temperature components.

NOTE 2 Materials that may crack or shatter under intense thermal shock conditions should not be used in liquid oxygen systems, e.g. during system filling.

NOTE 3 At extremes of temperature the dimensions and properties of many non-metallic materials change, for which allowance should be made, particularly when designing stressed components.

5.3.1 Non-metallic materials shall be odourless and non-toxic.

5.3.2 Dyes and pigments used for colouring shall be fast in the presence of human perspiration, or exhaled breath.

5.3.3 Non-metallic materials, when worn in contact with the skin, shall be non-dermatitic, non-abrasive and hypo-allergenic.

5.3.4 All finishes shall be non-flaking.

5.3.5 Lubricants, anti-seizing, sealing and locking agents, shall conform to BS N 100-6.

5.3.6 Non-metallic materials shall not support fungus or mould growth when tested in accordance with BS 3G 100-2: Section 3: Subsection 3.3.

6 Couplings and connections

6.1 Replenishment couplings

6.1.1 In-situ replenishment facilities shall be provided with means to prevent excessive rates of charging resulting in dangerously high temperatures within the system.

NOTE 1 In gaseous systems, protect the first non-return valve to prevent the main supply supporting combustion immediately downstream of the charging point. A swept bend with an angle of not less than 90° and with a radius five times the outside diameter of the conducting pipe may be interposed, for example, immediately downstream of the charging point and filter (if fitted).

NOTE 2 Special care should be taken with piping geometry, so that if a burn through should occur at a feature such as a bend, the resulting torching flame should not impinge on nearby parts in such a manner as to exacerbate the hazard.

6.1.2 In-situ replenishment facilities provided for the primary system, shall be accessible from outside the aircraft and isolated from other service connections to prevent cross-contamination.

6.1.3 The dimensions of replenishment couplings for the supply of liquid oxygen to aircraft shall conform to BS C 5.

6.1.4 The dimensions of replenishment couplings for the supply of high pressure gaseous oxygen to aircraft shall conform to BS C 20.

NOTE Very high pressure gaseous storage systems require special replenishment procedures. For such systems a different form of replenishment coupling should be used in conjunction with special replenishment equipment.

6.2 Equipment connections

6.2.1 On units having more than one connection, the unions shall be arranged to prevent incorrect connections.

6.2.2 Connections used only for servicing and testing shall be of a different type from those used for other purposes.

6.2.3 Connections shall be locked to prevent inadvertent disconnections.

6.3 Quick disconnection couplings

6.3.1 Quick disconnection couplings shall be capable of being made, locked and separated with gloved hands.

6.3.2 If the connection fails to lock, the two halves of the connection shall be self-separating and be installed to provide evidence of its malfunction to the user.

NOTE Self-sealing couplings should be designed to minimize oxygen spillage or leakage during coupling or uncoupling.

6.3.3 Where electrical connections are combined with the coupling, the oxygen circuit shall be complete and shall be sealed before the electrical connections are made or broken.

7 Filters

7.1 Filters shall be provided at the replenishment point to prevent the ingress of particulate contaminants greater than 50 μm (nominal).

7.2 Filters shall be provided in oxygen system components to prevent contamination of, or damage to, valves and mechanisms. Filters shall be readily accessible for replacement or cleaning during overhaul.

NOTE 1 Filters should be provided immediately upstream of valves and controlling orifices.

NOTE 2 Filters are usually made of very small diameter metallic wire, and as such, a very slight addition of heat can cause hot spots in the wire. The use of materials such as pure nickel or monel can reduce the hazard of combustion (see BS N 100-6).

NOTE 3 Whilst filters trap most contaminants above a specific size, after some use they can become an area of combustion due to the high combustibility of any collection of fine particles. They should be frequently cleaned or replaced to reduce potential hazards.

8 Vent and relief devices

8.1 Containers used for the storage of oxygen shall have pressure limiting devices (e.g. bursting discs) to ensure that the pressure cannot rise above the proof pressure specified for the container.

8.2 Pressure limiting devices (e.g. relief valves) shall be provided to protect the system from pressure in excess of the component design limitations.

NOTE Excessive pressure may arise from failure of the normal regulating means.

8.3 In liquid oxygen systems at least two independent pressure limiting devices shall be provided. One of these devices shall be in direct communication with the container.

8.4 Operation of a relief device in a system shall discharge oxygen overboard.

NOTE In the case of a gaseous system, if no hazard is created, the system may be discharged within the compartment in which it is installed, provided that the compartment is freely vented.

8.5 All vent lines taking oxygen overboard shall be unrestricted and, apart from means to prevent the ingress of contamination, shall be free from U-bends and shall have a gravity fall to atmosphere to prevent the risk of blockage by ice.

9 Pressure joints

9.1 Seals

The design and configuration of the seal shall prevent the oxygen flow stream impinging directly onto the exposed surface of the seal, thereby preventing a risk of ignition due to impact by contaminants carried along in the flow stream.

NOTE 1 Seal locations are among the most likely combustion sites within an oxygen system. To decrease the risk created by these locations, the number of seals used should be minimized. Where they are used they should be shielded or removed from the flow stream.

NOTE 2 Where a material is used to facilitate a seal it should be selected in particular relation to the range of operating pressures.

NOTE 3 The seal should be contained to limit the strain arising from the applied stresses.

NOTE 4 The design of the retaining housing should be such that the seal cannot be damaged upon assembly, thereby precluding any loose particles or flakes from entering the main oxygen stream. The retaining housing should also be such that the seal is free to adjust itself to form an efficient seal.

9.2 Mating surfaces

The permanent deformation of mating surfaces to effect a seal, in the absence of a separate sealing member, shall not affect resealing.

NOTE 1 Special care should be taken in the use of non-resilient sealing materials or materials subject to creep under stress.

NOTE 2 Materials, including non-metals, are susceptible to accelerated oxidation and corrosion when under stress in an oxygen atmosphere. For this reason, the initial mechanical stress permitted in a joint should be limited, in relation to the materials used, by the design of the joint or, alternatively, by a controlled assembly torque.

9.3 PTFE tape

Any PTFE tape used shall be in accordance with BS 7786 for oxygen use. PTFE tape shall only be used with tapered threads and shall be applied as follows.

a) Remove all traces of previously applied tape and clean the threads in accordance with BS 5N 100-7.

b) Trim the width of the tape to suit the male thread length and cut the length of the tape to give approximately 1.5 to 2.5 turns on the male taper thread.

c) Wrap the tape around the male thread, stretching slightly. The direction of wrapping is to be such that the overlap will trail when the connector is screwed in.

d) Do not allow the tape to overlap the end of the thread. It may be set back 1 to 1.5 threads to ensure that tape does not protrude into any oxygen flow path inside the connection.

e) When tightening the male threaded connector, ensure that the tape rotates with it.

f) Tighten in accordance with the detailed requirements of the application.

g) The tape is to project from the connection by at least one thread width when it is fully screwed in position.

10 Moisture and ice accretion

10.1 Servicing operations shall include procedures to prevent ingress of moisture into the system.

10.2 The design and location of liquid oxygen equipment within an aircraft shall include protection against ice and moisture affecting the performance or function of adjacent electrical equipment.

10.3 Where moisture is introduced during normal use of the system, e.g. breathing masks and air supply to oxygen concentrators, the design of the system shall ensure protection against the adverse effects of this moisture or subsequent freezing.

NOTE The rapid expansion of high pressure gas at reducing valves and orifices results in substantial local reductions of temperature. This, coupled with the increased dew point arising from high inlet pressures, can result in accumulation of moisture and ice leading to malfunctioning of the associated mechanisms.

11 Control knobs and switches

11.1 Manual controls and switches shall be designed so that the user has no difficulty in gripping, or in operating the control with cold, or gloved, hands.

NOTE The design of control knobs or switches should be such that the application of excessive loads to the internal mechanism of the equipment is avoided.

11.2 Control knobs shall be of distinctive shape to assist both visual and tactile identification.

NOTE This is particularly applicable where protective or bulky clothing is to be worn.

12 Strength of materials

12.1 All parts of the system shall be designed to withstand the maximum pressure to which they could be subjected in the event of a system failure. The pressure will vary throughout the system and shall be controlled by a pressure limiting device, duplicated where necessary.

12.2 Pipes and couplings of the system shall be designed to withstand:

a) a design proof pressure of $1{,}5p_w$ without leakage or permanent distortion greater than that specified in the appropriate product specification; and

b) pressure not less than $3\ p_w$ without fracture or bursting.

Where p_w is defined as follows:

p_w is the normal maximum working pressure at the extremes of temperature for which that particular part of the system is designed.

The relief pressure for that part of the system shall be fixed at a value of $1.33\ p_w$.

12.3 Flexible hoses shall be designed to withstand the following conditions:

a) a design proof pressure of $2\ p_w$ without leakage or permanent distortion greater than that specified in the appropriate product specification; and

b) pressure not less than $4\ p_w$ without fracture or bursting.

Where p_w is as follows:

p_w is the normal maximum working pressure at the extremes of temperature for which that particular part of the system is designed.

The relief pressure for that part of the system shall be fixed at a value of $1.33\ p_w$.

12.4 All other components shall be designed to withstand the following conditions:

a) a design proof pressure of $1{,}5\ p_w$ without leakage or permanent distortion greater than that specified in the appropriate product specification; and

b) pressure not less than $2{,}0\ p_w$ without fracture or bursting.

12.5 When the complete system is subjected to a test pressure equal to p_w and tested in accordance with BS N 100-3 the leakage shall be within the design specification.

13 Soldering, brazing and welding

Soldered, brazed and welded joints, if left in the as-formed condition, may leave slag, roughness, porosity, or cracks which can generate or trap contaminants. The use of such joints shall be minimized in high pressure oxygen components. When the use of welds cannot be avoided, they shall be fully penetrative so that all contacting surface area is joined to prevent entrapment of particulates and eliminate uncleanable blind surfaces.

NOTE 1 Typical joints which fall into the category that cannot be easily cleaned include the following:

a) bourdon tube joints and blind ends;

b) joints between nipples and pipes;

c) joints between flexible metallic bellows and their end-pieces;

d) joints on metallic, flexible hoses.

NOTE 2 The crystalline structure of some materials can be modified by heat applied during manufacturing processes and so affect their mechanical properties.

14 Cleaning processes

14.1 Soldering, brazing and welding

Components, which have been subject to soldering, brazing or welding, shall be cleaned in accordance with BS N 100-7 to remove all traces of oil, grease and organic flux. Any flux used shall not impair conformance of the materials to BS N l00-2.

NOTE Fluxless jointing is preferred in order to eliminate these hazards.

14.2 Cleaning and purging

14.2.1 Before assembly all individual components shall be cleaned in accordance with BS N 100-7 to remove dust, swarf, metallic particles, oil, grease, machining lubricant, fluxes, test liquids and any other organic contaminants.

NOTE It is essential that particular attention be paid to "blind" holes to prevent the ingress of contaminants.

14.2.2 Following assembly or installation, assemblies or complete systems shall be purged with one of the gases specified in BS N 100-3.

14.2.3 After cleaning and before use, all external ports and pipe connections shall be protected against the ingress of contaminants (see BS N 100-7).

15 Installation of equipment

15.1 The number of parts of the system subject to high or very high oxygen pressures (see Table 1), shall be kept to a minimum and where possible those parts shall be isolated from crew and passenger compartments.

15.2 Where ventilation is used to prevent accumulation of hazardous quantities of oxygen, the ventilation system shall not entrain other potentially hazardous substances.

16 Identification marking

16.1 Oxygen cylinders shall be marked with the following information:

a) the symbols "O_2 (AV)" in stencilled lettering;

b) the normal maximum working pressure at a stated temperature.

NOTE 1 Cylinders may in addition bear the name of the gas.

NOTE 2 The International Standard for colour coding of gas cylinders, ISO 448 has now been withdrawn. It is normal UK practice for aviation oxygen storage cylinders to be coloured black with a white 360° section at the valve end. In the USA, for example, the conventional colour for oxygen storage cylinders is green.

16.2 Pipelines shall be marked with identification symbols in accordance with BS M 23.

Bibliography

BS N 100, *Aircraft oxygen systems and equipment.*

BS N 100-4, *Guide to the physiological factors.*

BS 5N 100-7, *Aircraft oxygen systems and equipment — Part 7: Guide to cleaning, labelling and packaging.*

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