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Aircraft oxygen systems and equipment —

Part 4: Guide to the physiological factors

ICS 49.090

British Standards

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee ACE/38, Aircraft oxygen equipment, upon which the following bodies were represented:

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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The following BSI references relate to the work on this standard:

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Foreword

This Part of BS 4N 100 has been prepared by Technical Committee ACE/38 and provides guidance on the physiological factors to be considered when designing equipment for use with oxygen. It partially supersedes BS 3N 100 which is withdrawn upon publication of all seven parts.

BS 4N 100 consists of the following 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.*

NOTE The latest revision of an aerospace series standard is indicated by a prefix number.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 5 and a back cover.

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1 Scope

This part of BS 4N 100 provides guidance on the physiological factors which should be considered when designing oxygen systems for use within aircraft.

2 Normative references

The following normative documents contain provisions which, through reference in this test 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 2N 3*, Specification for gaseous breathing oxygen supplied for airborne application.*

3 Definition

For the purposes of this standard the following definition applies:

3.1
hypoxia (oxygen deficiency)
any state wherein a physiologically inadequate amount of oxygen is available to, or is utilized by, tissue; without respect to cause or degree of inadequacy.

4 Physiological effects of altitude

4.1 The known requirements for oxygen during flight are shown in Table 1. They are based on physiological information and refer to healthy adults.

4.2 Oxygen supplied for airborne applications shall conform to BS N 3.

Table 1 — Oxygen requirements at altitude

Condition	Metres	ft (Ref.)
Maximum altitude without oxygen at which night vision is not seriously impaired.	1 219	4 000
Maximum altitude without oxygen at which flying efficiency is not seriously impaired.	2 438	8 000
Altitude below which decompression sickness is highly unlikely.	5 486	18 000
Altitude above which the incidence of decompression sickness increases rapidly with exposures exceeding 10 minutes.	7 620	25 000
Maximum altitude at which sea level physiological conditions can be maintained by breathing oxygen (94 % minimum) at ambient pressure.	10 058	33 000
Maximum allowable altitude without breathing oxygen (94 % minimum) at a pressure greater than ambient.	12 192	40 000
Maximum altitude from which a rapid descent can be made with the use of a correctly fitted pressure breathing mask and appropriate oxygen regulating device providing 12 192 m (40 000 ft) is reached within 2 minutes.	15 240	50 000
Altitude above which some form of pressure clothing is essential, the type depending upon the duration of exposure.	15 240	50 000

5 Relation of oxygen requirements to aircraft operation

5.1 In order to offset the physiological disturbances referred to in Clause **4**, the aircraft cabin should be pressurized to an equivalent altitude of 2 438 m (8 000 ft) or lower when oxygen is not used, or to not higher than 7 620 m (25 000 ft) when added oxygen is breathed.

5.2 Under the emergency conditions which follow the loss of cabin pressure of a pressurized aircraft, some lack of oxygen can be accepted in resting passengers. Thus, unconsciousness is unlikely to occur if the cabin altitude does not exceed 7 620 m (25 000 ft), provided that descent is made to an altitude below 3 962 m (13 000 ft) within 5 minutes. Furthermore, loss of consciousness is unlikely to occur during an exposure of resting individuals at altitudes up to 3 962 m (13 000 ft) lasting several hours, although moderate to severe impairment of the ability to perform functional tasks will occur.

5.3 Unless oxygen is administered at high cabin altitudes, unconsciousness and, finally, death will occur. The time of onset of unconsciousness is dependent on the cabin altitude, the rate of decompression and physical activity of the individual. (For example, without added oxygen the "time of useful consciousness" at 7 620 m (25 000 ft) is approximately 3 minutes, and at 12 192 m (40 000 ft) it is 20 seconds.)

5.4 When cabin altitude following failure of the pressure cabin does not exceed 10 668 m (35 000 ft), impairment of consciousness can be avoided by administration of oxygen as the cabin altitude rises above 3 048 m (10 000 ft). If, following a sudden decompression (period of decompression less than 1 minute), the cabin altitude exceeds 10 668 m (35 000 ft), significant hypoxia can only by avoided by breathing an oxygen-enriched air mixture before the decompression and administration of oxygen (94 % minimum) from the early stages of decompression. If the cabin altitude exceeds 12 192 m (40 000 ft), pressure breathing shall be applied.

6 Protection against smoke and noxious gases

The use of oxygen (94 % minimum), together with precautions against inward mask leakage, provides suitable breathing protection against smoke and noxious gases.

NOTE Generally, protection of the eyes will also be required.

7 Physiological requirements for aircraft oxygen equipment

7.1 The primary purpose of aircraft breathing equipment is to maintain adequate oxygenation of the user on ascent into a rarefied atmosphere while imposing the minimum of interference with breathing and general efficiency. For military aircraft this could be throughout the entire flight envelope; for commercial aircraft (pressurized) this will only be required during an emergency.

7.2 The minimum concentration of oxygen in the gas delivered by the breathing equipment should maintain a partial pressure of oxygen in the inspired gas that is not less than the normal ground level value as specified in Def Stan 00-970, Part 1/2, Section 6.13 (December 1999) (for military applications), or JAR 25.1443 (for commercial applications). This requirement can only be achieved at cabin altitudes below 10 058 m (33 000 ft).

The use of high concentrations of oxygen in aircraft is not desirable in circumstances in which the crew may be exposed to prolonged accelerative forces such as occur in aerobatic manouevres and this may give rise to chest discomfort and coughing due to local lung collapse). In these circumstances, the concentration of oxygen provided by the breathing equipment at a given altitude should not exceed that specified in Def Stan 00-970, Part 1/2, Section 6.13 (December 1999).

In order to limit impairment of consciousness due to lack of oxygen following sudden decompression (a duration of decompression of less than 1 minute) to a final altitude in excess of 10 668 m (35 000 ft), the minimum concentration of oxygen breathed should be that specified by Def Stan 00-970, Part 1/2, Section 6.13 (December 1999) but ideally oxygen (minimum 94 %) should be breathed from the commencement of the decompression.

NOTE It is generally accepted that a certain degree of hypoxia can be tolerated by seated passengers in the emergency of exposure to cabin altitudes in excess of 3 048 m (10 000 ft). In these circumstances the minimum concentration of oxygen in the gas delivered at the lips should be adequate to maintain a partial pressure of oxygen of 13.3 kPa[1)] to 11.2 kPa (inspired gas saturated with water vapour at 37 °C) depending on the altitude. (See JAR 25.1443c).

[1)] kPa =1 kN/m^2 = 0.01 bar.

7.3 The breathing equipment should not impose an undesirable degree of impedance to breathing with the breathing patterns that occur during flight. The form of the breathing pattern is determined principally by the level of physical activity. It is also modified by emotional disturbances, speech and lack of oxygen. The breathing equipment should be capable of high maximum instantaneous inspiratory and expiratory flows (e.g. up to 3.3 l/s with a maximum rate of change of flow of 20 l/s^2. (See Def Stan 00-970, Part 1/2, Section 6.13 (December 1999).

In many applications, such as passenger supply systems, it may not be necessary to provide a capability as high as 3.3 1/s since, in the case of seated passengers exposed to altitudes greater than 3 048 m (10 000 ft) the respiratory minute volume is unlikely to exceed 25 1/min and the maximum instantaneous respiratory flow will probably not exceed 1.3 1/s, but in all cases, the impedance should be as low as possible. During a respiratory cycle, total changes of pressure at the lips not exceeding 250 Pa (1 inch water gauge) when the peak inspiratory and expiratory flows are 0.5 1/s and 1 kPa with the peak at 3.3 1/s represent negligible resistance to breathing (impedance).

NOTE Volumes (in litres) are based on ATPD: volume of dry gas at ambient temperature and pressure.

7.4 Various methods of storing oxygen in aircraft may result in the gas leaving the storage system at a temperature which differs considerably from that of cabin ambient[2)]. The temperature of the gas at the lips should be within ±5 °C of ambient cabin temperature.

[2)] Liquid oxygen systems may deliver gas from the storage container at a temperature lower than the cabin ambient, while chemical oxygen generators may produce gas at a temperature considerably higher than cabin ambient.

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Bibliography

Def Stan 00-970, *Design and airworthiness requirements for service aircraft:*

Volume 1: *Aeroplanes*

Volume 2: *Rotorcraft*

Jar 25 Joint Aviation Requirements JAR 25

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