

PAS 95:2011

Hypoxic air
fire prevention
systems –
Specification



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Foreword

This Publicly Available Specification (PAS) was sponsored by the following companies: AcecoTI, Colorado Altitude Training, COWI, FirePASS Group, Hypoxic Technologies, LPG Fire, Opsys, Prevenex Europe and Wagner Group – all members of the Summit Air Institute for Preservation, Health and Safety (SAIPHS). Its development was facilitated by the British Standards Institution (BSI). It came into effect on 16 November 2011.

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- FirePASS Group.
- Gotland University.
- LPG Fire.
- Prevenex Europe.
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Use of this document

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentation conventions

The provisions of this PAS are presented in roman type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, recommendations, explanation and general informative material is presented in smaller italic type, using the heading NOTE, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a PAS does not in itself confer immunity from legal obligations.

Introduction

0.1 General

Hypoxic air fire prevention systems provide a means of inhibiting the development of flaming fires and thus of preventing fires from causing significant damage. They differ from fire-extinguishing systems in that they provide a continuous level of prevention rather than a discharge of extinguishing agent once a fire has been detected.

Normal air is a mixture of oxygen and nitrogen, together with small quantities of argon, carbon dioxide and other gases. Oxygen is the critical element that supports both life and combustion. When the oxygen content is intentionally lowered for special applications, the resulting gas is called hypoxic air or reduced-oxygen air.

Hypoxic air environments are used for physical training and rehabilitation of athletes and in medical research. Fire prevention is another, more recent and evolving application for such systems; Annex A details the concept.

Hypoxic air fire prevention systems are applied in installations where it is possible to control the environment of the protected spaces, either exclusively for fire prevention or in combination with other indoor climate control (e.g. temperature, humidity). They may be used in, for example, archives, vaults, computer facilities, warehousing and cold storage.

Hypoxic air fire prevention systems used in the protection of artefacts and other materials affected by oxidation (e.g. food, paper, paintings, metals) can reduce oxidative degradation.

0.2 Health and safety

Hypoxic environments created for the purpose of fire prevention are precisely controlled and monitored reduced-oxygen environments that should not be confused with other environments where hypoxic conditions can occur in an uncontrolled, unwanted or unexpected way. Hypoxic air fire prevention systems are “clean air” systems based on adjustment of the partial pressure of oxygen, and the atmosphere produced in the protected spaces is essentially the same in character as atmospheres found at altitude and in commercial aircraft cabins.

However, all hypoxic environments are potentially dangerous, and precautions need to be taken if it is intended to have people enter such environments to

undertake activities. Low oxygen levels are hard to detect without appropriate monitoring, and there is serious danger to human life where this is not done correctly. Therefore, all people entering a hypoxic environment should be made aware of the reduced oxygen level, of the risks and of the safeguards and the need to stick to them. They should know what the low-oxygen emergency alarm sounds like.

As hypoxic fire-protected spaces are enclosed environments, they are subject, in the UK, to *The Confined Spaces Regulations 1997*. Accordingly, each hypoxic air fire prevention system installation has to undergo a suitably detailed hazard and risk assessment, sufficient to meet the requirements of *The Management of Health and Safety at Work Regulations 1999*, including consideration of the suitability of such a system for the specific application at its location and any protective measures required for the health and safety of all individual people having access to the protected space for all activities to be undertaken.

The Confined Spaces Regulations 1997 detail the safeguards to be taken when working in enclosed spaces, and this PAS details some of the precautions to be taken when dealing with hypoxic air fire-protected spaces. These precautions are determined by the level of oxygen within the protected space and the kind of activities to be undertaken there. As noted, more strenuous activities will require a higher oxygen intake, which may be harder to achieve in a hypoxic environment.

As oxygen levels reduce, so it becomes increasingly important to have adequate provisions in place to protect the health and safety of all people in hypoxic air fire-protected spaces, especially those who may be predisposed to be adversely affected by reduced oxygen levels, such as pregnant women or those with certain medical conditions. Activity levels that have minimal impact on people at higher oxygen levels can have more significant impact at reduced oxygen levels, and so the health implications of raised activity levels in hypoxic environments need to be considered for all individual people entering such an environment.

In atmospheres of reduced oxygen concentration levels, the suitably detailed and sufficient hazard and risk assessment may require people to use breathing apparatus routinely or for specific activities and/or in emergency situations.

1 Scope

This Publicly Available Specification (PAS) specifies requirements for the design, installation, testing and maintenance of hypoxic air fire prevention systems in protected spaces.

This PAS defines the limits of use of such systems.

This PAS is not applicable for fire-extinguishing systems covered by the BS EN 15004 series.

This PAS does not contain recommendations relating to the suitability of hypoxic air fire prevention systems for particular applications or the selection of such systems in the context of the overall fire risk.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 5839-1:2002+A2:2008, *Fire detection and fire alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance*, Clause 25

BS EN 54-4, *Fire detection and fire alarm systems. Power supply equipment*

BS EN 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems. Requirements for electrical/electronic/programmable electronic safety-related systems*

BS EN 15004-1, *Fixed firefighting systems – Gas extinguishing systems – Part 1: Design, installation and maintenance*

3 Terms and definitions

For the purpose of this PAS, the following terms and definitions apply.

3.1 air separation system

system capable of adjusting and controlling the chemical composition of air

3.2 competent person

individual (or organization) that has the requisite training and experience, can access the requisite tools, equipment and information, and is capable of carrying out a defined task to a specified standard

3.3 control panel

component that receives and sends signals to other components of the system (e.g. building management system, fire detection alarm system), with control, monitoring and measurement functions, and alarm and annunciation features, to maintain the design oxygen concentration level in the hypoxic environment of the protected space

3.4 design oxygen concentration level

oxygen concentration level in percentage by volume used as the design basis for a hypoxic air fire prevention system specification for a particular application

NOTE *The design oxygen concentration level cycles between minimum and maximum values as the hypoxic air fire protection system maintains the hypoxic environment. The range between the minimum and maximum values defines the design operating range of the system for the particular application.*

3.5 flushing

process during which the air separator system is shut down and the air in the protected space is replaced with fresh air

3.6 hold time

period of time that the oxygen concentration level in a protected space remains at or below the maximum oxygen concentration level after the hypoxic air fire prevention system has been shut down

3.7 hypoxic air

air in which the oxygen concentration level has been artificially reduced from its normal level for a specific purpose

3.8 hypoxic air fire prevention system

system designed to create and maintain a hypoxic environment to prevent or inhibit fire

3.9 hypoxic air generator

air separation system that produces hypoxic air with an oxygen concentration level greater than 10% by volume

3.10 ignition-limiting oxygen threshold

oxygen concentration required to limit ignition and prevent sustained flaming combustion of materials when tested in accordance with specified standard procedures

NOTE *Annex B specifies the test method.*

3.11 indoor air climate (of the hypoxic air fire prevention system)

operating climate, taking into account fresh air composition (normally exclusively via the hypoxic air fire prevention system), temperature and humidity

3.12 infiltration

uncontrolled passage of external air into the protected space through unintended leaks (e.g. cracks between wall sections, roof-wall interface, around windows and doors)

NOTE 1 Infiltration is often expressed as a percentage of the volume of the protected space per hour.

NOTE 2 The test methods described in ISO 16000-8:2007 and the equivalent NT VVS 118:1997 are suitable means of measuring infiltration under non-pressurized conditions. Room integrity test methods using a pressure differential cannot be applied without a valid calculation to correct for influence of pressure.

3.13 nitrogen injection system

air separation system that produces an output with an oxygen concentration level less than 10% by volume

3.14 normobaric air pressure

atmospheric air pressure at sea level

3.15 normoxic air

air having an oxygen concentration level of 20.9% by volume

3.16 operator

natural or legal person (or organization) having authority for the use and technical operation of the hypoxic air fire prevention system (as designated in the system logbook)

3.17 oxygen alarm level

oxygen concentration level at the maximum or minimum of the allowable range of oxygen concentration levels, beyond the oxygen monitoring system's tolerance, specified for fire prevention in the protected space and that triggers an alarm

3.18 oxygen monitoring system

automatic electronic system capable of measuring the oxygen concentration level within a hypoxic environment

NOTE The oxygen monitoring system can be equipped with chemical, electrochemical, infrared, ultrasonic or other types of sensors allowing reliable oxygen monitoring.

3.19 protected space

enclosed space containing the hypoxic environment

3.20 safety factor

oxygen concentration level reduction (minimum 1% by volume) from the ignition-limiting oxygen threshold

3.21 tolerance

explicit range of allowed values within the oxygen monitoring system's measurements

4 Use and limitations

4.1 General

The design, installation, testing and maintenance of hypoxic air fire prevention systems shall be performed by competent persons.

4.2 Limitations on installation

Hypoxic air fire prevention systems shall not be installed for use in areas where:

- a) sufficient infiltration control cannot be achieved;
- b) an alternative source of oxygen is present;
- c) oxidizing agents exist that have the potential to reduce oxygen concentration by chemical reaction (e.g. chlorine);
- d) substances or processes exist that evolve gases capable of modifying the atmosphere such that the oxygen concentration is reduced (e.g. toxic displacement);
- e) the hazard and risk assessment (see 4.3) identifies any other contraindication to their use.

4.3 Hazard and risk assessment

Design and installation of hypoxic air fire prevention systems shall follow a suitably detailed hazard and risk assessment, including consideration of the suitability of such a system for the specific application at its location and any protective measures required for the health and safety of all persons having access to the protected space.

NOTE 1 Hypoxic air fire prevention systems should not be used in conjunction with smoke control systems.

NOTE 2 A hypoxic environment cannot prevent non-oxidizing smouldering or pyrolysis.

NOTE 3 Hypoxic air fire prevention systems may not offer full protection in the following areas:

- a) where explosive gases (or explosive mixtures of gases), particulates and liquids are present, or where there is the possibility of explosive atmospheres being created within the range of system operating oxygen concentration levels;
- b) where reactive metals, gunpowder, metal hydrides, hydrazine and other chemicals capable of autothermal decomposition are handled or stored;
- c) where chemicals containing oxygen available for combustion (e.g. cellulose nitrate) are present.

5 System design

5.1 Planning

The following objectives shall form the basis of the planning process:

- a) to create and maintain an environment in the protected space that is effective in preventing fire;
- b) to create a hypoxic environment that does not pose a risk to persons.

5.2 Provisions

The design of the hypoxic air fire prevention system and of its programme of operation shall include provision for:

- a) access control to prevent unauthorized access to the protected space;
- b) coordination and integration with the fire safety strategy for the building and protected space;
- c) integration with other systems within the building and with the building itself (e.g. fire alarm, building management, ventilation, environmental);
- d) where the system is integrated into an air-conditioning system utilizing remote air-handling units (AHUs) that serve the protected space, air tightness of the ductwork and the AHUs that may contribute to the infiltration;
- e) modification of the physical construction of the protected space (e.g. building, room), by sealing or other techniques, to enable retention of the hypoxic environment so as to meet the maximum allowable infiltration of external non-hypoxic air as specified by the system designer;
- f) detection of non-oxidizing smouldering or pyrolyzing processes that can occur in the hypoxic air environment by means of a high-sensitivity smoke detection system, taking into account the airflows, possible ignition and restrained combustion scenarios within the protected space;

NOTE An example is an overheating cable with pyrolysis of the plasticizer coating: a flaming fire will not develop from this in a correctly designed hypoxic air environment, but detection of the event is desirable to signal and enable remedial action.

- g) assessment of infiltration, taking into account the access requirements of persons, the function and behaviour of all ventilation and environment control systems, and any other features or systems that may impact on the retention of the hypoxic environment;
 - h) construction of the protected space in such a way that it presents a barrier to fire spreading from adjacent non-protected spaces for a time period determined by local regulations or the building fire safety strategy;
 - i) air locks or space interfaces to prevent infiltration through access events;
 - j) flushing in the event of toxic or harmful gases accumulating. In such cases, a hypoxic air fire prevention system installation shall not be appropriate unless the system can be shown to negate the creation of hazardous concentrations;
- NOTE** The capability for flushing should be designed into the hypoxic air fire prevention system only if approval is obtained from the local fire service. In addition, prior to flushing, insurers should be notified in the same way as when a sprinkler system is impaired or taken offline.
- k) making all data relating to the design oxygen concentration level, in conjunction with the duration of time persons will spend in the protected space and the level of activity undertaken while there, available for incorporation into the health and safety policy;
 - l) determining the design oxygen concentration level appropriate to the types of "reasonable worst case" materials to be found in the protected space;

NOTE 1 If materials present are unknown, the efficiency of this protection approach cannot be assured.

NOTE 2 Some combustibles contain variable amounts of chemically bonded oxygen, some may contain normal air in pockets (e.g. bubble wrap), and stored combustibles may be plastic wrapped. The combustibles should be assessed by ignition-limiting oxygen threshold and behaviour in defined tests (see Annex B).