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# Oxygen reduction systems for fire prevention — Design, installation, planning and maintenance



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# Foreword

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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).

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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 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 8, *Gaseous media and firefighting systems using gas*.



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.

# Introduction

Oxygen reduction systems are designed to prevent fires from starting or spreading, by means of the introduction of oxygen reduced air and creating an atmosphere in an area which is having lower permanent oxygen concentration in respect to ambient conditions. Oxygen reduction systems are not designed to extinguish fires. The design and installation are based on detailed knowledge of the protected area, its occupancy and the materials in question. It is important to suit the fire protection measures to the hazard as a whole.

# Oxygen reduction systems for fire prevention — Design, installation, planning and maintenance

## 1 Scope

This document specifies minimum requirements and defines the specifications governing the design, installation and maintenance of fixed oxygen reduction systems with oxygen reduced air for fire prevention in buildings and industrial production plants. It also applies to the extension and modification of existing systems.

This document applies to oxygen reduction systems using nitrogen-enriched-air which are designed for continual oxygen reduction in enclosed spaces.

NOTE Nitrogen is, today, the most suitable gas to be used for oxygen reduction. For other gases, this document can be used as a reference.

This document does not apply to:

— oxygen reduction systems that use water mist or combustion gases;

— explosion suppression systems;

— explosion prevention systems, *in case of chemicals or materials containing their own supply of oxygen, such as cellulose nitrate*;

— fire extinguishing systems using gaseous extinguishing agents;

— inertization of portable containers;

— systems in which oxygen levels are reduced for reasons other than fire prevention (e.g. steel processing in the presence of inert gas to avoid the formation of oxide film);

— inerting required during repair work on systems or equipment (e.g. welding) in order to eliminate the risk of fire or explosion.



In addition to the conditions for the actual oxygen reduction system and its individual components, this document also covers certain structural specifications for the protected area.

The space protected by an oxygen reduction system is a controlled and continuously monitored indoor climate for extended occupation. This document does not cover unventilated confined spaces that can contain hazardous gases.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 7240 (all parts), *Fire detection and alarm systems*

EN 12094-1, *Fixed firefighting systems — Components for gas extinguishing systems — Part 1: Requirements and test methods for electrical automatic control and delay devices*

EN 50104, *Electrical apparatus for the detection and measurement of oxygen — Performance requirements and test methods*

## 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:

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

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

**3.1**
**alarm threshold**
value of a process parameter which, when reached, triggers an alarm and, where necessary, initiates automatic protection measures

**3.2**
**design concentration**
oxygen concentration level determined by subtraction of the safety margin from the ignition threshold

Note 1 to entry: See also Figure 1 and Table 2.

Note 2 to entry: The design concentration represents the maximum oxygen concentration which shall not be exceeded at any time.

**3.3**
**combustible material**
material capable of combustion or being ignited



Note 1 to entry: For the purposes of this document, whether the quantity of a combustible material is to be regarded as significant or not should be determined by means of a risk analysis as part of the fire protection design.



**3.4**
**ignition threshold**
maximum oxygen concentration in a mixture of a combustible material with air and inert gas, in which there can be no ignition, determined under established test conditions

Note 1 to entry: This is a specific characteristic of combustible material and inert gas (see A.1).

**3.5**
**detection and alarm installation**
remote detection system for the reliable detection of risk to people and property

**3.6**
**measuring zones**
virtual separation of the protected volume for oxygen measuring

**3.7**
**normal operation**
situation in which the equipment, protection systems and components are able to carry out their designated functions within their design parameters

**3.8**
**oxygen reduced air**
air with an oxygen concentration lower than that in normal atmospheric conditions

**3.9**
**oxygen reduced air supply**
nitrogen enriched air stream with an oxygen concentration lower than that in normal atmospheric conditions, ready to be introduced into a protected volume

**3.10**
**protected volume**
space to be protected by oxygen reduction system

Note 1 to entry: Protected volume is measured in cubic meters.

**3.11**
**system**
combination of components whose function and compatibility guarantees the safety of the installation

**3.12**
**technical area**
area where the control panel, the nitrogen-enriched-air production unit and/or other relevant system components are placed

**3.13**
**control panel**
electrical device for monitoring, controlling and operating the alarm and other functions of the oxygen reduction system

## 4 System requirements

### 4.1 General



An oxygen reduction system shall consist at its minimum of:

a) a supply of oxygen reduced air;

b) a fixed pipework system with fittings, valves, nozzles, outlets;



c) oxygen sensors and control panel;

d) alarms.

Oxygen reduced air is produced by air separation or by injecting inert gas or gas mixture into the protected area.

The oxygen concentration in the protected area shall be monitored by means of measuring equipment. During operation, the supply of nitrogen-enriched air shall be controlled automatically according to demand. Where necessary, as a result of a risk analysis, additional means shall be provided to operate the supply manually or an additional supply operated manually or automatically.

The oxygen reduction system can be equipped with automatic equipment designed to shut down machinery and to close fire doors and other equipment, with the aim of creating and maintaining the required oxygen concentration.

The level of oxygen reduction is defined by the individual risks of these areas (see Annex A).

Individual components should comply with the relevant technical standards, if they exist.

Alternatively, for electrical/electronic/programmable electronic safety related systems, IEC 61508 (all parts) should be used.

### 4.2 Personnel safety

Oxygen reduced air can be dangerous for personnel within protected volumes, technical areas housing the oxygen reduction systems and adjacent areas.

Requirements for unventilated confined spaces do not necessarily apply to space protected by oxygen reduction systems that control and continuously monitor indoor climate for extended occupation.

Personnel safety measures shall be made for the fact that neighbouring volumes can have a reduced oxygen concentration. These areas may also need to be monitored and/or personnel safety measures may need to be taken.

Technical or organizational measures shall be taken to prevent unauthorized people from entering protected areas with permanently reduced oxygen levels.

The measurement system shall be designed in such a way that a loss of function or a measurement error can in no event lead to the minimum oxygen threshold not being detected.

The spreading of the oxygen-reduced atmosphere to other areas not intended for this (e.g. through wall openings, cable ducts, floor drainages, leaking doors, conveyor belts) shall be prevented.

### 4.3 Effectiveness and application

A fire risk assessment detailing the key fire protection factors shall be undertaken. The assessment should take into account:

— the type and quantity of material/materials requiring protection;

— the area(s) requiring protection;

— the right dimension of the oxygen reduced air supply to maintain the reduced oxygen concentration on its design value;

— a back-up oxygen reduced air supply, if provided;

— alarm equipment.



Oxygen reduction systems provide preventive fire protection. The introduction of nitrogen-enriched-air reduces the oxygen concentration of the air, thereby preventing the ignition or spread of fire except for the following:



— chemicals containing their own supply of oxygen (e.g. cellulose nitrate);

— mixtures containing oxidizing materials (e.g. sodium chlorate or sodium nitrate);

— chemicals capable of undergoing autothermal decomposition (e.g. some organic peroxides);

— reactive metals (e.g. sodium, potassium, magnesium, titanium and zirconium), reactive hydrides or metal amides, some of which may react violently.

NOTE While oxygen reduction systems cannot prevent ignition of the fuels listed above, they can prevent the spread of fire to other fuels which can offer protection to surrounding infrastructure (e.g. the building structure).

### 4.4 Alarm organization and emergency plan

An alarm organization is required for the following purposes:

— to alert affected and responsible persons;

— to alert the permanently attended location;

— to initiate other necessary protective measures.

The responsibilities for the alarm organization shall be defined.

The emergency plan should cover key words to designate the basic measures that need to be taken in case of emergency, too low oxygen levels or fire signal.

# 5 Design

## 5.1 Qualification of the designer

The designer shall be sufficiently technically qualified to ensure effective protection.

## 5.2 Fire protection concept

The system design shall be part of the fire safety concept of the building.

As part of the system design, a fire risk assessment may lead to further fire protection measures.

EXAMPLE Since the oxygen reduction system cannot prevent or detect smouldering or pyrolizing processes (e.g. overheated cables), suitable smoke detection systems for the protected volume (e.g. highly sensitive smoke detection systems according to ISO 7240-20 class A) are installable as part of the main fire alarm system of the facility.

Where special circumstances deviate from what is covered in this document (e.g. spatial configuration, structure, installations, combustible materials, altitude different from sea level, temperature different from normal, fumes or gases, requiring special measures) the designer shall take these into account.

## 5.3 Structural specifications for the protected area

Structural partitions shall comply with the criteria governing the protection target, as shown in Table 1. Building regulation specifications are unaffected by these measures.



**Table 1 — Structural partitions**



| Level | Protection target | Protected volume | Specification | Achieved by |
|---|---|---|---|---|
| **1** | The contents of a room shall be protected from internal fires. | Room | Enclosing elements (walls, floor and roof) shall be sufficiently air tight[a] over the life time to protect from internal fires. | — |
| **2** | The contents of a room shall be protected from internal fires and from fires spreading from an external source. | Room | Enclosing elements (walls, floor and roof) shall be sufficiently air tight[a] over the lifetime and provide protection against the spread of fire from the surrounding area. | The construction of fire compartments according to the relevant guidelines. |

[a] Openings shall be constantly sealed or sealable; otherwise, the openings shall be reflected in the calculation of the nitrogen-enriched-air production.

The user should be aware of the relationship between leakage, reduced oxygen air supply and the system duty cycle.

In the case of oxygen reduction systems, all operational openings that are not included in the calculation of the required levels of oxygen shall be provided with closing mechanisms or monitored via limit switches. These operational openings include emergency exit doors and other doors, gates, etc.

## 5.4 Oxygen concentration

The following information should be used (where relevant) to determine the design concentration:

— combustible material present (in normal operation and in the case of maintenance work or faults);

— geometry of the combustible materials (e.g. hollow items, thin walls);

— volume of gas contained in combustible materials (e.g. hollow parts, densely packed storage items);

— temperatures and pressures in the protected area;

— safety margin between oxygen concentrations established experimentally and the oxygen concentrations required for the design of the oxygen reduction system.

## 5.5 Oxygen reduction to prevent fire

NOTE 1 Ignition can only be prevented in protected areas if the oxygen concentration within the protected area does not exceed the design concentration. If this level is exceeded, the protection objective of "fire prevention" can no longer be guaranteed.

If different combustible materials are present in the protected area, the lowest ignition threshold (i.e. the most ignitable material in its most ignitable geometry) shall be taken as the basis for determining the design concentration. In individual cases, additional tests can be carried out to establish ignition thresholds for combustible materials in the forms and geometry in which the materials are actually present.

Testing shall be conducted according to Annex A.

NOTE 2 Authorities having jurisdiction can include requirements beyond this document.

The following are examples where the test described in A.2 may not be appropriate when the protected volume contains:

— high voltage electrical equipment;

— toilet paper;

— clothing in bales;

— stored goods which may allow a large amount of oxygen to enter the warehouse.



In no case shall the oxygen concentration be higher than specified in Annex A.



Ignition thresholds for oxygen reduction using nitrogen-enriched-air for various applications are given in A.1. Values obtained with mixtures of other gas components can differ from these figures. These concentrations are determined under the specific test conditions described in A.2.

Concentrations other than those shown in Table A.1 can be achieved and allowed when the test is validated by test reports in accordance with A.2. Materials not listed in Table A.1 should be tested in accordance with the test in A.2 and validated by test reports. The design of oxygen reduction systems shall take into account the ignition levels and the safety margins described in 5.6. This design concentration shall not be exceeded anywhere in the protected area. In case of any fault arising, action shall be taken according to the emergency plan (see 5.7.2).

**WARNING — Where stored goods may allow a large amount of oxygen to enter the warehouse, the test structure and the test described in A.2 may not be sufficient. In such cases, an appropriate design concentration is the subject of agreement with the authority having jurisdiction. Such cases may include, for example, warehouses containing toilet paper or clothing in bales.**

## 5.6 Safety margins

The safety margin for oxygen reduction systems shall be set at 0,75 % oxygen by volume.

The difference between the design concentration and the warning threshold, or warning threshold and operating range, is established according to the combustible materials, operation and fault related fluctuations in time and place of the inert gas concentration, the time needed for protection measures and emergency action to take effect, and the tolerance of the oxygen monitoring facilities.

Definitions of concentration margins shown in Table 2 are as follows:

— Oxygen sensor tolerance: This margin covers the technical measuring errors.

 