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

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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

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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).

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 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.

— Operating margin 1 (warning): this margin takes into account the operational fluctuations in time and place of the oxygen concentration to avoid false warnings, related to the warning threshold for maximum oxygen concentration (see Clause 4).

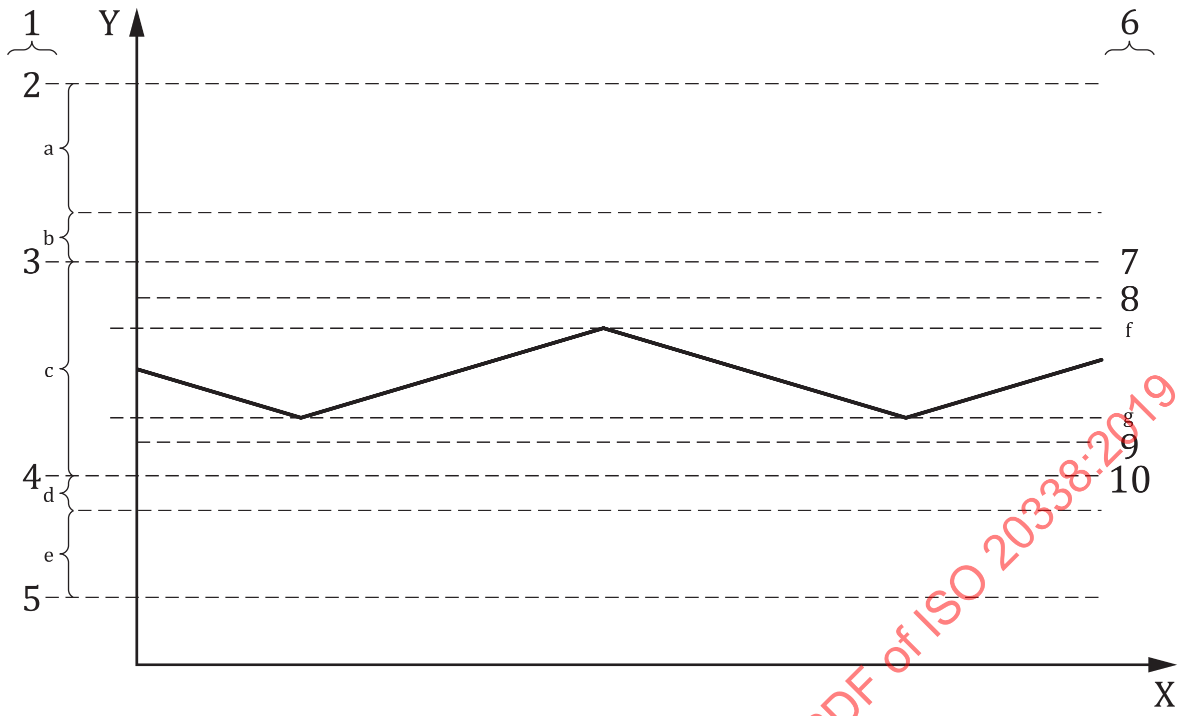
— Operating margin 2 (pre-warning): this margin takes into account the delay before protective measures take effect and alarm delays of the measuring device monitoring the oxygen concentration. Operating margin 2 is dependent on the system configuration, the emergency concept and the expected hold time.

— Working range high: this margin ensures a sufficient cycle time for the operation of the oxygen reduced air supply.

— Working range low: this margin ensures a sufficient cycle time for the operation of the oxygen reduced air supply.

— Operating margin 3 (pre-alarm): this margin takes into account the delay before protective measures take effect and alarm delays of the device monitoring the oxygen concentration. Operation margin 3 is dependent on the system configuration and the emergency concept.

— Pre-alarm threshold for minimum oxygen concentration Operating margin 4 (alarm): this margin determines the alarm value for the minimum oxygen concentration to avoid false alarms.



Key

X time

1 design values

2 ignition threshold

3 maximum O_2 concentration

4 minimum O_2 concentration

5 value for risk management

6 alarm and warning levels

7 O_2 max warning

8 O_2 max pre-warning (see NOTE 1)

9 O_2 min pre-alarm (see NOTE 1)

10 O_2 min alarm

Y O_2 concentration

a Safety margin.

b Oxygen sensor tolerance.

c Design operation range.

d Oxygen sensor tolerance.

e Altitude correction.

f Oxygen reduced air supply ON.

g Oxygen reduced air supply OFF.

NOTE 1 Keys 8 and 9 are optional as it is only required if distribution valves are not monitored (see 5.7.3).

Figure 1 — Control diagram for oxygen reduction

Table 2 provides an example for the calculation of the oxygen concentration with different design values at an altitude of 300 m.

Table 2 — Example for the calculation of the oxygen concentration

Design values	**Margin** Vol.-%	**O_2 concentration** Vol.-%	**Remarks**
Ignition threshold		16,0	
Safety margin	−0,75		
Design concentration		15,25	
Oxygen sensor tolerance	−0,2		
Maximum O_2 concentration		15,05	**O_2 max warning**
Operating margin 1 (warning)	−0,2		

Table 2 *(continued)*

Design values	Margin Vol.-%	O_2 concentration Vol.-%	Remarks
Pre-warning O_2 concentration		14,85	**O_2 max pre warning (optional)**
Operating margin 2 (pre-warning)	−0,2		**(optional)**
Oxygen reduced air supply ON		14,65	
Working range high	−0,2		
Target value		14,45	
Working range low	−0,2		
Oxygen reduced air supply OFF		14,25	
Operating margin 3 (pre-alarm)	−0,2		**(optional)**
Pre-alarm O_2 concentration		14,05	**O_2 min pre alarm (optional)**
Operating margin 4 (alarm)	−0,2		
Minimum O_2 concentration		13,85	**O_2 min alarm**
Oxygen sensor tolerance	−0,2		
Altitude correction	None		**Altitude 300 m (less than 700 m)**
Value for risk management		**13,65**	

5.7 Oxygen reduced air quantity

5.7.1 Continuous oxygen reduction

When determining the oxygen reduced air flow required for continuous oxygen reduction, the following factors shall be taken into account:

— the target value;

— the leak rate under normal operating conditions (including door openings, air locks and sluices and frequency of the operation of those openings per day);

— the concentration of the oxygen reduced air;

— the period of operation.

To determine the necessary capacity for the protected volume (under normal operating conditions), an additional 25 % shall be added to the calculated flow rate.

The basis for determining the leak rate of the protected volume can be, for example, a Door Fan Test according to ISO 14520-1, or a test for determination of local mean ages of air in buildings for characterizing ventilation conditions according to ISO 16000-8. In addition, air leakage due to normal operation (e.g. through airlock entrances) shall be taken into account.

5.7.2 Emergency plan

An emergency plan that describes the progress of the oxygen concentration in the event of a failure of the oxygen-reduced air shall be formulated. If there is a risk that after activation of the O_2 max warnings the design concentration is reached and a danger situation in the protected area cannot be ruled out, contingency measures shall be taken. Contingency measures can be either technical or organizational measures.

The emergency plan shall be discussed with all those responsible for fire protection and, where applicable, personnel safety.

5.7.3 Oxygen reduced air

The oxygen reduced air system shall be able to deliver reliable supplies of the required quantity and quality of gas for maximum specified demand periods (e.g. more frequent access to such areas, higher rate of movements of goods in and out of a warehouse, wind load). All associated protected areas and their requirements according to 5.7.1 shall also be taken into account.

The system and, if applicable, the reserve supply of oxygen reduced air shall be monitored, see also Clause 7. Measures to be taken in the event of a fault shall be detailed in the emergency plan.

NOTE The reliability can be achieved for example by:

— monitoring the operating position of the manual stop valves located in the gas flow;

— monitoring the function of the oxygen reduced air production system and/or supply;

— monitoring the oxygen reduced air flow by means of flow monitors.

The oxygen reduced air shall be free of dangerous impurities and have a maximum volumetric concentration of oxygen 2,3 %Vol. below the target value.

5.7.3.1 System using containers

If the oxygen-reduced air is stored in containers, the reliable quantity of oxygen reduced, air shall be available for the required demand.

A fault alarm shall be issued as soon as this quantity is no longer sufficient to maintain the design concentration for the period required for refill.

5.7.3.2 System using vaporizer

The necessary oxygen-reduced air shall be available at all times and if it is a stand-alone system, no other uses shall be allowed for the vaporizer and the supply. If it is a back-up system, additional uses for the supply can be allowed.

The oxygen-reduced air supply shall be monitored for faults. Should there be a problem with the oxygen-reduced air supply, a fault alarm shall be displayed on the control panel.

5.7.3.3 System using oxygen-reduced air production equipment

The necessary oxygen-reduced air production equipment shall be available at all times and shall be dedicated only to fire prevention purposes.

If back-up solutions (e.g. liquid nitrogen) are used, they shall assure at all times the necessary availability of oxygen reduced air.

The oxygen reduced air production equipment shall be monitored for faults.

5.7.4 Fault signals

All relevant deviations from the normal operation of the oxygen reduced air system shall trigger a fault signal on the control panel. These include:

— failure of the oxygen reduced air supply;

— measured oxygen concentration in the protected volume out of design operating range;

— the possible misalignment of section valves from their operating positions, or as an alternative the oxygen concentration in the protected zone could be used. In this case, a pre-warning and pre-alarm level shall be implemented;

— abnormal operating range of the generator (e.g. by low or too high pressure, concentration below 10 % of the normal operating range, high temperatures);

— short-circuit or open-circuit of all operation and alarm lines;

— failure of any oxygen sensor;

— breakdown of power supply.

5.8 Technical areas

5.8.1 Technical area for control panel

The control panel should be located in a designated area, which is not subject to major fire risk, and should not be set up in the protected volume itself. If the control panel is located inside the protected volume, a display for the actual oxygen concentration shall be visible from outside close to the entrance of the protected volume and it shall be possible to switch off the oxygen reduced air supply from the outside.

The location of the control panel shall comply with the following minimum requirements:

— be easily accessible;

— be protected against unauthorized access;

— maintain a minimum temperature range between 0 °C and +50 °C or specified by the manufacturer;

— be designed such that maintenance work and inspections can be carried out easily;

— have electrical lighting.

The operating instructions shall always be displayed in a prominent position.

5.8.2 Technical area for reduced oxygen air generation

The technical area for reduced oxygen air generation shall:

— have ventilation or in the case of closed volumes, the technical area should be equipped with an oxygen sensor;

— be easily accessible;

— be protected against unauthorized access;

— maintain a minimum temperature range between 0 °C and +35 °C or specified by the manufacturer;

— be designed such that maintenance work and inspections can be carried out easily;

— have electrical lighting.

Components installed in the technical area shall be protected against excessively high temperatures caused by exposure to the sun or other heat sources.

The technical area shall be separated from neighbouring volumes such that any components of the oxygen reduction system located in that space are protected against mechanical and chemical influences.

The following information about the oxygen reduction system shall be provided by the installer:

— name of the installer (where applicable the name of the maintenance company);

— year of installation or of any significant changes;

— operating and maintenance instructions and other important information;

— pipework and control diagrams;

— floor plans showing the protected areas.

6 Distribution pipework

6.1 Pipework

Pipework, pipe connections and integral moulded parts and components shall be able to withstand the relevant working pressures, environmental aspects, fluids, gases and temperatures for their expected lifetime. The rated pressure shall be no less than the maximum anticipated system pressure. In case of possible closed pipe sections, the maximum anticipated system pressure is the maximum compressor outlet pressure.

Only non-combustible materials may be used outside the protected area. Within the areas protected by oxygen reduction systems, plastic pipes may also be used, although brittle plastics or plastics liable to brittleness are not allowed. Pipes shall be located to avoid mechanical damage or protected against mechanical damage where this is not possible. Flexible pipes and hoses, etc. may only be used where rigid pipework is unsuitable.

The pipework shall be suitable for installation in the prevailing environmental conditions (e.g. corrosion-resistant).

All pipework shall be accessible and clearly marked for identification.

In case of metallic pipework, the pipe network shall have equipotential bonding.

6.2 Pipe supports

All supports shall be able to withstand the relevant static and dynamic loads.

Supports may not be used for other purposes. The supports shall be fixed close to pipe connections.

6.3 Components in the pipework

Fittings, valves and shut-off devices shall comply with the relevant standards. All fittings shall be accessible. Valves shall be secured at least against unintentional obstruction or misalignment of the operating position. This can be done for example by removing the control lever. If there is a risk of unauthorized access to a valve with manual operation option, the relevant valves shall be monitored by fitting limit switches or other proper oxygen sensors on their operational positions. The inlets (e.g. nozzles or outlet holes) shall be arranged such that the required homogenous oxygen-reduced air concentration is established and the difference in the oxygen level should not differ more than 0,5 Vol % within the protected volume, not considering direct influence of openings and inlets up to a distance of 1 m.

This needs to include consideration of known leakage areas and their position.

To achieve even distribution, at least one nozzle or outlet hole per 150 m^2 should be installed. For volumes higher than 10 m, an additional level of nozzles/outlet holes should be installed.

Alternatively, the oxygen reduced air flow can be applied directly into a Heating/Ventilation/Air Conditioning system (HVAC). This makes it possible to support the homogenous distribution of the oxygen reduced air.

In case a HVAC is used to distribute oxygen-reduced air, it shall be assured that the HVAC continues to operate (e.g. energy backup, redundant air condition, monitoring).

WARNING — Permissible operating excess pressures shall be maintained in the compartment air system.

The pressure and volume rate/production rate of the oxygen reduced air supply shall be taken into account in this process.

Temperature and pressure fluctuations shall be taken into account.

7 Monitoring the oxygen concentration

In an oxygen reduction system, the monitoring process is carried out by directly measuring the oxygen concentration. The measurement shall always be taken by at least three independent oxygen sensors per protected volume (see Table 3) and at least one oxygen sensor per measurement zone.

Table 3 — Minimum amount of measuring zones

Volume in m^3		Minimum amount of measuring zones	Minimum amount of oxygen sensors
from	to		
>0	500	1	3
>500	4 000	4	4
>4 000	10 000	6	6
>10 000	25 000	8	8
>25 000	50 000	10	10
>50 000	100 000	12	12
>100 000	200 000	14	14
>200 000	300 000	16	16
>300 000	400 000	18	18
>400 000		Case by case evaluation	Case by case evaluation

The measuring zones shall be evenly distributed through the perimeter of the volume (height and area).

Every protected volume with a separate inlet shall be considered as an individual volume. Closed false floors and ceiling voids with less than 10 % opening are also considered as individual volumes. In addition to Table 3, the location, number and type of measuring zones shall be determined based on the actual hazard.

This means taking into account:

— ventilation conditions, air flow, exhaust air;

— environmental conditions (e.g. large spaces, built-in components);

— areas of negative impact (e.g. airlock entrances);

— other individual conditions that may have an effect on the mixture of the oxygen reduced air atmosphere.

In the case of oxygen reduction systems, only oxygen measuring systems with proven suitability, measurement range and display range for this application shall be used.

The measuring zones of the oxygen measurement shall be arranged such that the measured data provides information about whether the oxygen concentration in the entire protected volume is outside the specified range (warning and alarm threshold), see Figure 1.

Measuring points should be in the well-mixed zone away from reduced oxygen air supply inlets and openings to avoid nuisance alarms or undue activation of the oxygen reduced air supply.

The oxygen concentration shall be measured continuously by each sensor, at least one time per minute.

The measuring devices shall be suitable for use in the prevailing environmental conditions (e.g. temperature, water vapour, pollution, catalyst poisons). Any sensitivity errors and the subsequent effects on the precision and the necessary maintenance intervals of the measuring devices shall be taken into account.

The precision and response times shall be documented.

It is recommended that measurements of oxygen concentrations within the protected area are displayed constantly. The oxygen sensing devices shall comply with EN 50104.

The system is operational if not more than one oxygen sensor or 20% of the oxygen sensors, whichever is higher, is non-operational.

8 Alarms and notifications

When alarm or warning thresholds are reached (see 5.6) notifications shall be issued according to the emergency plan and automatic protection functions or organizational measures introduced.

The control panel shall display the following visual and acoustic signals:

a) alarms triggered by reaching the lower alarm thresholds. In this case, the lowest value of all measuring points shall be taken as a basis;

b) warning triggered by reaching the upper warning threshold. In this case, the highest value of all measuring points shall be taken as a basis;

c) warning if one oxygen sensor is outside 0,5 % of the average for at least 10 min;

d) system faults (collective fault);

e) shutdown of the oxygen reduction system (fault alarm);

f) faults at the oxygen sensor for oxygen or auxiliary quantities and their monitored forms of transmission.

The faults shall be displayed on the control panel as a collective fault and the alarms as individual alarms. The transmission of the collective fault and the alarms shall be carried out according to the definition of the emergency plan. In the case of the alarm, an acoustic and visual signal shall be provided in the protected area and an indication at the designated access points of the protected area.

The alarm devices (horns and flashing lights) shall comply with the requirements in ISO 7240-3 and ISO 7240-23.

In the case of a system fault, the alarm reports shall still be displayed on the control panel.

The average oxygen level shall be displayed as an operational notification at the access points of the protected area and at the oxygen reduction monitoring equipment. This should also work under power failure or routine maintenance conditions.

Signs indicating the oxygen-reduced atmosphere shall be located at all entrances (see Figures 2 and 3).

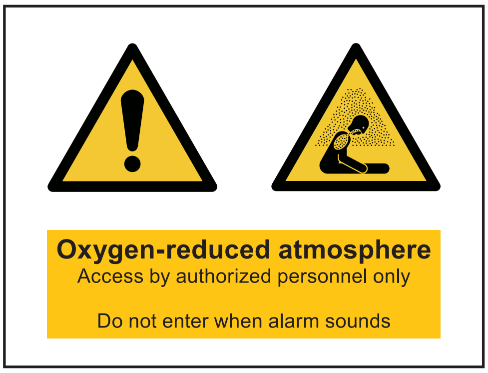


Figure 2 — Example of a combination sign (ISO 7010-W001 "General warning sign", ISO 7010-W041 "Warning; Asphyxiating atmosphere" and a supplementary text sign) at the entrance to an oxygen-reduced area

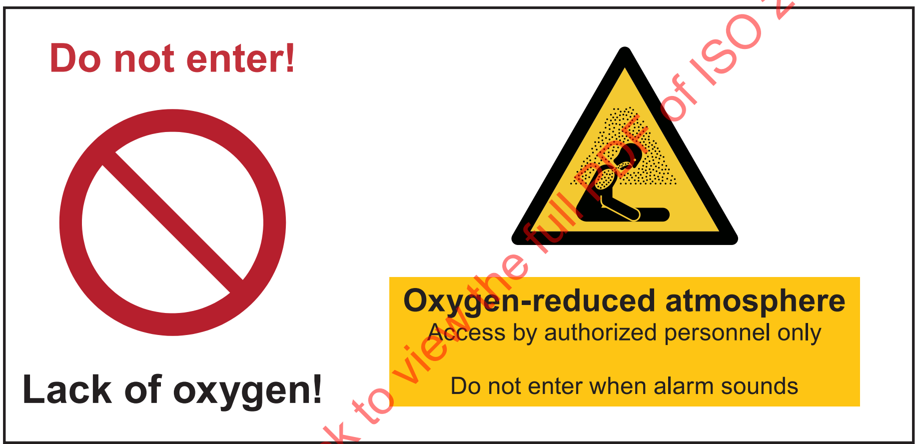


Figure 3 — Example of a combination sign (ISO 7010-P001 "General prohibition sign", ISO 7010-W041 "Warning; Asphyxiating atmosphere" and a supplementary text sign) at an entrance to an oxygen-reduced area in the case of alarm

An audible alarm should sound if the oxygen concentration is below the O_2 minimum alarm threshold.

The alarm should be heard from every location within the area with an oxygen-reduced atmosphere. This should be ensured by way of a redundant acoustic and/or acoustic and visual alarm.

The O_2 min alarm should also be prominently automatically signalled by an uninterrupted illuminated panel or visual signal and sign at all entrances to the oxygen-reduced areas (see Figure 3).

The alarm may only be switched off once it has been ensured that all personnel have left the protected area and that unauthorized persons can no longer access the oxygen-reduced areas due to the presence of the illuminated panels and/or visual signal at all entrances to the areas at risk or by closing off entrances.

9 Control equipment

9.1 Function

A control panel collects, processes and, where applicable, transmits readings of oxygen or other measurements, alarms, fault indication on monitored equipment, changes of status and resource control. The wiring to safety-related components shall be monitored for broken wires and short circuits.

A detection and alarm installation creates alarm reports from automatic or manually input information, issues these and detects any faults. The transmission channels for information and alarms are monitored. Special measures are in place to prevent any malfunction as far as possible, which may be powered electrically or otherwise. Detection and alarm systems cover facilities for the input, transmission (through wires or wirelessly), processing and issuing of alarms, including the necessary power supply. This document applies to detection and alarm systems which detect and report the scale of the risk at an early stage.

9.2 Requirements

Electrical equipment for control purposes shall be designed such that defects or functional faults of a signal processing unit of a software-controlled control panel or any fault in the primary wiring (broken wires or short circuits) cannot allow more than one protected area to fail.

Where applicable, the requirements of ISO 7240 (all parts) and EN 12094-1 apply to the control panel of the oxygen reduction system.

All equipment forming part of the control of the oxygen reduction system shall be designed such that personnel safety is ensured at all times. This does not just apply to intended operational conditions but also in the case of faults. Proof of effectiveness shall form part of the risk analysis (e.g. ISO 12100).

9.3 Electrical power supply

The electrical power supply and the design of the emergency power timeframe shall comply with the specifications of ISO 7240-4.

The emergency power supply for control of the system shall be a minimum of 24 h or national guidelines are an alternative.

9.4 Electrical cabling installations

The relevant national standards should be taken into account when installing the electrical cabling of the oxygen reduction system.

The electrical cabling shall meet the following specific requirements:

— The cables shall be properly protected from foreseeable operational risks.

— The electrical cables should, as far as possible, be laid through protected areas.

— The cables shall be protected and arranged in a way that limits any damage in the event of fire to an absolute minimum.

— Cables, in particular for purposes of control and alarm equipment, shall be designed to maintain function in case of fire for at least 30 min.

9.5 Data recording

The system design shall enable the following data to be recorded and stored for a minimum of 12 months:

— average oxygen concentration (at least every 10 min);

— alarms;

— warnings;

— fault indications;

— operating and stand-by time.

A method shall be provided to retrieve information for analysis without compromising existing storage or continuing data storage. Where this storage is not provided by external systems such as the building management system, the oxygen reduced air prevention system shall incorporate storage of this information.

10 System operation

10.1 Instruction and training of personnel

At least two responsible persons shall receive instruction from the installer in the operation of the system.

The responsible persons should be trained for this work and know what their duties are as well as having knowledge of oxygen reduction systems.

Areas with permanently reduced oxygen levels shall be part of access control. Unauthorized personnel shall be prevented from having access to protected areas (see Figure 2).

Personnel entering or working in the protected area or neighbouring areas shall be given regular instructions by the operator. The instructions shall include the following:

— description of the access control measures for the protected area;

— codes of behaviour within the protected area.

10.2 Inspections

At least once a year, system inspections shall be carried out in order to ensure operational readiness. The inspections shall be carried out in accordance with the information provided by the installers and in line with the manufacturer's recommendations.

The validity of the calibration of the oxygen sensors shall be checked. The inspections shall be carried out by qualified and competent persons, who are specially trained for this work and who know exactly what their duties are as well as having comprehensive knowledge of oxygen reduction systems.

10.3 Operations log

An operations log shall be kept. The following entries shall be made:

— inspection reports;

— maintenance, oxygen sensor calibration and repair work (reason, type, date);

— all other events which affect the oxygen reduction system (e.g. change in design operating range, shutdown, faults, alarms).

10.4 Further obligations

If any changes (e.g. fire risk, room sealing, ventilation) that may have a negative impact on the effectiveness of the oxygen reduction system are made, the installer and appropriate authorities (if applicable) shall be informed and the oxygen reduction system adjusted accordingly.

Changes and extensions to the oxygen reduction system shall be carried out by qualified and competent persons/companies who are familiar with the system.

If the oxygen reduction system reaches concentrations above the design operation range, adequate protection measures (e.g. fire watch) should be carried out.

11 Maintenance

Regular maintenance work, including periodic inspections, shall be carried out in order to ensure operational readiness. The maintenance shall be carried out in accordance with the information provided by the installers and in line with the manufacturer's recommendations.

The maintenance shall be carried out by qualified and competent persons/companies, who are specially trained for this work and who know exactly what their duties are as well as having comprehensive knowledge of oxygen reduction systems.

Maintenance work shall be carried out in such a way that the shutdown is as short as possible with minimum disruption. In the case of multiple area systems, the protected areas can be shut down one after another to minimize disruption.

Oxygen sensors need to be calibrated according to the interval of the manual of the oxygen sensor.

In the event of a failure repair work shall be carried out as quickly as possible.

12 Documentation

The installer shall provide technical information about the evaluation of the risks and the effectiveness of the oxygen reduction system.

The installer shall verify the risk analysis carried out as a basis for the design of the oxygen reduction system.

At least the following information shall be provided:

— name of the owner and location of the risk;

— drawings on a scale no smaller than 1:100;

— the protected hazard;

— the protection target;

— the necessary oxygen reduced air quantities, volume flow rates and spare capacity;

— location and details of the oxygen reduced air supply;

— description of the emergency oxygen reduced air reserve supply, if applicable;

— emergency plan;

— isometric drawings showing the internal diameter and length of pipes;

— arrangement of nozzles/outlet holes;

— type and arrangement of monitoring, alarm and control equipment;

— type, arrangement and precision of oxygen sensors;

— other information necessary for the evaluation of the installation of the oxygen reduction system (e.g. pressure test certificate);

— operation, inspection and maintenance instructions;

— possible risk to the surrounding area.

The installer shall provide information about the time required by the system to achieve the design concentration from start-up.

The name of the installer, the maintenance company, the year of installation, the operation, inspection and maintenance instructions and other important information about the oxygen reduction system (e.g. operating instructions with pipework and control diagrams of the oxygen reduction system and a floor plan showing the area protected by the oxygen reduction system) shall be available near the control panel.

13 Installation

13.1 Qualification of the installer

The installer shall be qualified and competent, specially trained for the work and know exactly what duties are expected of them, as well as have comprehensive knowledge of oxygen reduction systems.

Where special circumstances, such as spatial configuration, structure, installations or combustible materials, require special measures that ensure the proper function of the oxygen reduction system, the installer shall take this into account.

13.2 General specifications — Installation

All components shall be installed in such a way that inspection and maintenance can be carried out easily at all times.

The components, pipework and electrical cables shall be installed in such a way that the risk of damage by fire or by mechanical or chemical agents is as low as possible.

Measuring equipment shall be arranged in such a way that pollution (e.g. through dust) cannot occur. Otherwise, the measuring equipment shall be protected accordingly.

The pipework shall be checked to be free from obstructions, contaminations and dirt during installation.