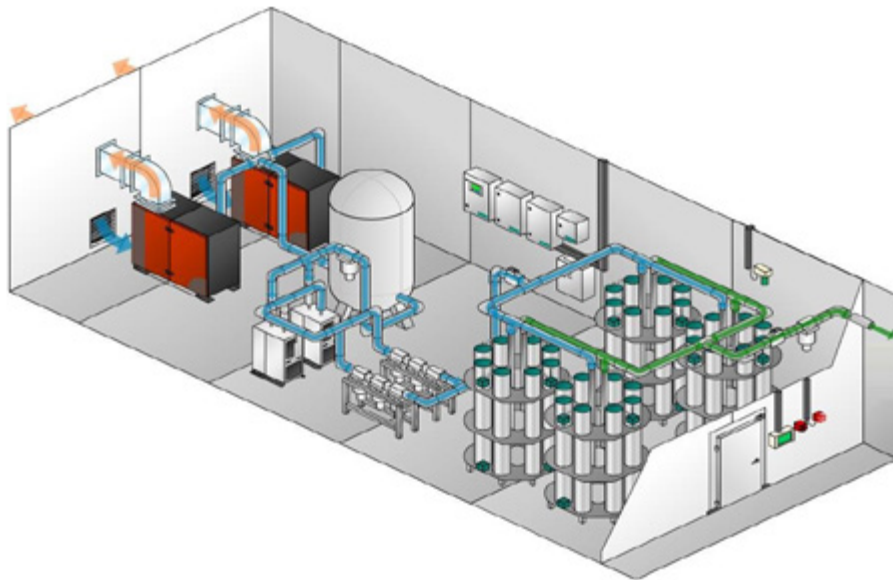


# OXYGEN REDUCTION SYSTEMS

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This Tech Talk discusses oxygen reduction systems (ORS) for fire prevention at industrial and commercial properties.

Oxygen reduction system layout

## AT-A-GLANCE

- ORS are designed to prevent the occurrence or spread of fires
- An ORS can be considered by ARC if it provides additional benefit to an active fire protection system and if the overall loss control concept is reliable
- Attention must be given to the design, installation and maintenance of these systems with ARC involvement

## INTRODUCTION

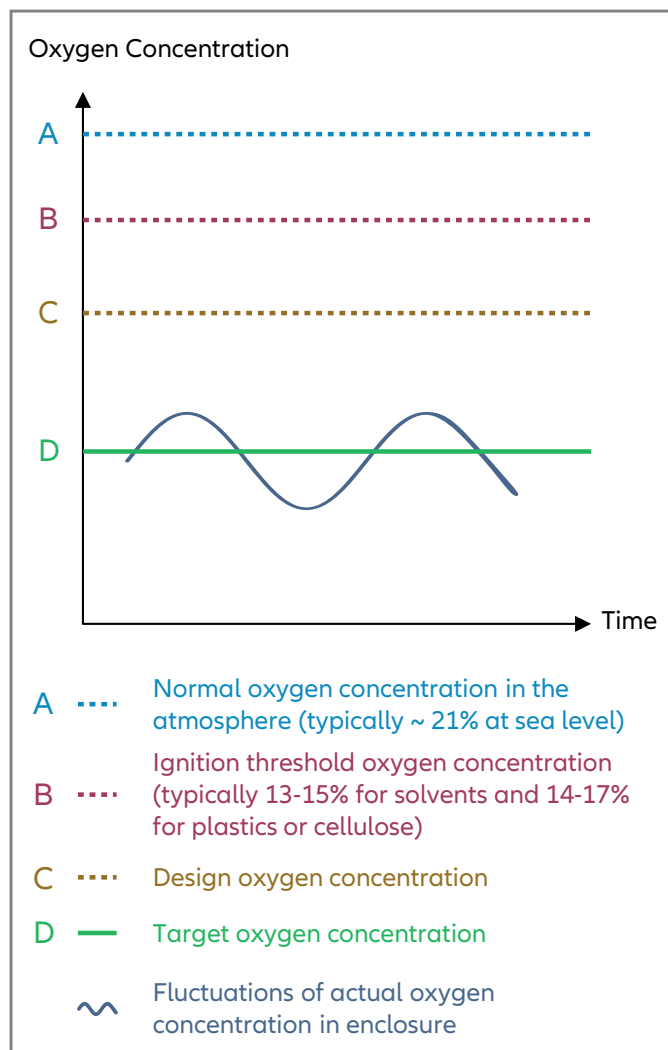
Oxygen reduction systems (ORS) are frequently promoted by clients and suppliers as an alternative to an active fire protection system, such as automatic sprinklers. This Tech Talk provides insight into the principles and characteristics of ORS. In addition, ARC's position and recommendations are detailed.

# THE TECHNOLOGY

ORS inject inert gas (nitrogen) into the protected area to lower the oxygen concentration. They are designed to prevent the occurrence and/or spread of fire. ORS are often misunderstood and are frequently compared to inerting systems or gaseous extinguishing systems.

- Inerting systems inject inert gases into an enclosure and are designed to prevent the formation of explosive mixtures of gases, vapors or dusts.
- Gaseous extinguishing systems use inert or so called "chemical" gases to extinguish fires after they start.
- ORS, on the other hand, are designed to **prevent a fire** from occurring within an enclosed occupancy.

ORS are sometimes referred to as "fire protection systems", but this is contradictory and confusing. ORS are fire prevention systems.



Oxygen concentration levels

The ignition threshold oxygen concentration (B) is experimentally determined by laboratory tests for ORS design. Several materials and liquids have been tested and VdS Standard 3527 Annex B lists ignition threshold values for a number of different products.

Testing shows that there is no risk of fire spread when the oxygen concentration is below the ignition threshold, but there is an extremely rapid progression of the fire getting out of control only several tenths of a percent above that threshold. As a result:

- There is no linear correlation between the development of a fire once the ignition threshold is exceeded. Therefore, caution is required when determining the design oxygen concentration of an ORS, especially for the storage of mixed commodities.
- There is a need to monitor and control the oxygen concentration in an enclosure to ensure it remains well below the ignition threshold. Standards recommend using a design oxygen concentration (C) with a rather large safety margin.

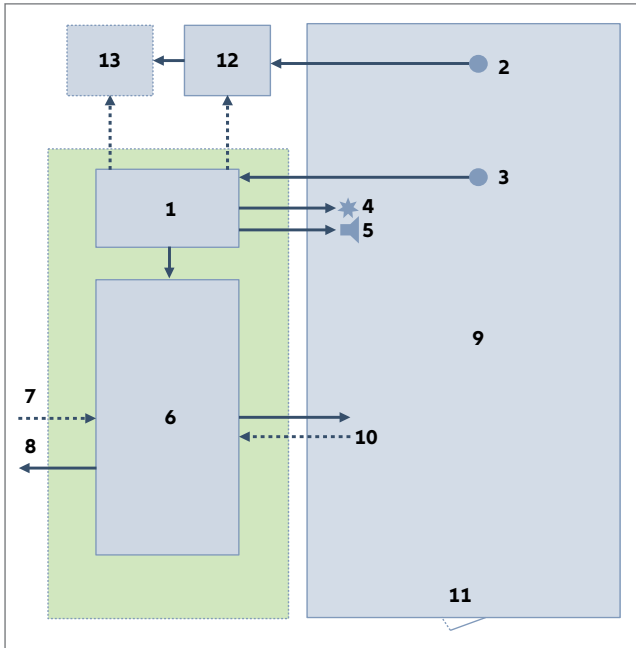
Testing also shows that once a fire starts, it will continue at oxygen levels much lower than the ignition threshold, or even the design concentration (auto-extinguishing oxygen concentrations were sometimes as low as 7%). That is why it is important to include a smoke detection system and manual firefighting operations with all ORS.

When properly designed, the ORS should control the actual oxygen concentration in the enclosure to ensure it stays below the design oxygen concentration (C), while avoiding frequent operation. This is known as the target oxygen concentration (D) (the target value for the concentration controller).

An example of the oxygen concentrations (% volume) for two types of commodities:

		High-density polyethylene (HDPE)	Paper (writing paper, 80g/m <sup>2</sup> , white, untreated)
A	Normal oxygen concentration	21.0%	
B	Ignition threshold oxygen concentration	16.0%	14.1%
C	Design oxygen concentration	15.0%	13.1%
D	Target oxygen concentration	14.8%	12.9%

As soon as the system detects a concentration equal to the design oxygen concentration (C), nitrogen is injected to lower the oxygen level to the target oxygen concentration (D) for the commodities present.



Oxygen reduction system schematic (plan view)

1. Control panel and power supply
2. Smoke detection system
3. Oxygen concentration sensors
4. Strobe light
5. Annunciator
6. Nitrogen generator (membrane or adsorption)
7. Ambient air (optional)
8. Oxygen enriched air out
9. Protected area (unoccupied)
10. Air exchange (ambient ventilation and infiltration not shown)
11. Access
12. Fire detection and alarm system
13. Building management system

## ARC POSITION

ARC does not typically consider a stand alone ORS as an alternative solution to active or passive fire protection systems.

To consider the use of an ORS, the following concerns must be addressed:

- ORS must provide an additional benefit to an active fire protection system.
- ORS alone is not sufficient. The overall fire prevention concept should combine an active fire protection system, very early warning fire detection, alarm transmission, manual firefighting supported by an adequate fire water supply, and fire walls (optional).
- Discuss accessibility issues with the local fire officials, which could be a significant life safety concern in some jurisdictions due to the reduced oxygen concentration in the protected space.

Normally unoccupied spaces for which this type of system may be useful include, but are not limited, to the following:

- Deep freeze warehouses and cold storage
- Storage of products sensitive to smoke and/or water contamination, such as pharmaceuticals, electronics, food, etc.

- Storage of valuable goods, such as art, paintings, books, archives, etc.
- Storage of luxury goods, such as jewelry, leather, clothing, etc.
- Data centers

## ARC RECOMMENDATIONS

Before installing an ORS, please contact ARC to discuss the proposed application. The following should be considered during the design and installation process:

### 1. Key design elements

- a. Design and install the ORS in accordance with the latest edition of VdS 3527: *Oxygen Reduction Systems, Planning and Installation* (Germany).
- b. Select a reputable contractor who has significant experience in the design, installation and maintenance of ORS.
- c. Consider ORS for new construction projects only. Building tightness and preventing leaks are key performance issues for ORS. Maintaining building tightness over time is a huge challenge for smaller rooms and is even more difficult for large spaces like a warehouse. Client experience indicates the installation of an ORS in an existing warehouse regularly fails due to leaks and the challenges of maintaining building integrity. This lack of tightness leads to either the inability to reach the required design oxygen concentration or the need to inject additional nitrogen into the building on a regular basis, which dramatically increases operating costs. Several systems have been shut down for this reason.
- d. Install ORS in normally unoccupied areas only. According to feedback from ARC clients, stringent medical surveillance for personnel entering low oxygen atmospheres has led to the permanent deactivation of the ORS. While outside the scope of property loss prevention, life safety is a serious concern in low oxygen atmospheres. Globally, health & safety administrations require limited and controlled access to areas with oxygen concentrations below 17%.
- e. Conduct a feasibility study to validate all potential consequences with respect to health & safety of personnel in all foreseeable situations (i.e. permanent workplace, maintenance work, emergency response, etc.). Evaluate all administrative requirements (i.e. legal, workers' council, etc.) as well. Note that compromising on design oxygen concentrations or even target oxygen concentrations for life safety reasons is not an acceptable option.
- f. Calculate the long term operating costs of the system especially with regard to electricity consumption. Require the supplier to include these costs in any long-term agreement. Scrutinize the maintenance costs, including foreseeable leakage in the building/room over time.
- g. Provide adequate training for maintenance personnel with regard to operation, maintenance and inspection of the ORS. These systems have higher technical requirements for monitoring and controlling the required oxygen concentration in the enclosure. This is crucial, especially for high volume air spaces like warehouses.

- h. Detail the manual firefighting concept for enclosures protected by the ORS.
  - i. Continuously monitor the oxygen concentration with alarms transmitted to a constantly attended location. Most suppliers offer remote monitoring capabilities, which can improve system operation and reliability.
  - j. Do not install an automatic heat/smoke venting system in the protected area.
  - k. Never install battery charging equipment within the protected enclosure.
- b. Follow ARC Fire Protection Impairment Management procedures for the ORS. Consider the system to be impaired when the ignition threshold oxygen concentration is reached or exceeded. When long term maintenance operations are required in the area, the best engineering practice is to increase the oxygen level to 17% or the lowest level allowed by the local health & safety administration. The area is vulnerable to fires during this time and all required safety measures should be taken.

## 2. Technical requirements

- a. Ensure the nitrogen production is reliable in case of machinery breakdown. Back-up equipment will be needed to ensure nitrogen can be produced at all times.
- b. Size the nitrogen production equipment to provide 120% of the minimum required supply.
- c. Confirm the control panel has an independent battery, sized to provide a minimum of 72 hours continuous operation in case of loss of electrical power.
- d. Connect all equipment to an adequately sized emergency generator.
- e. Oxygen concentration:
  - Provide a 1% safety margin for the design oxygen concentration as referenced in VdS 3527. For example, a material with an ignition threshold oxygen concentration of 17% would require a design concentration of 16%.
  - In general, the listed ignition threshold oxygen concentration minus the safety margin is sufficient, but recent tests performed by recognized laboratories have demonstrated that care was required in certain circumstances. It is suggested that alternative test methods are needed to characterize very specific commodities. Since determining the design oxygen concentration is a key parameter, this should be discussed and reviewed with ARC prior to signing any contracts.
- f. Install a listed/approved air-aspirating smoke detection system in the protected area.
- g. Record the oxygen concentration rate for the enclosure every three months and submit to ARC for review and comment.

## 3. Acceptance and impairment

- a. Inspection, testing and maintenance of the system should be conducted by qualified personnel in accordance with the ORS manufacturer guidelines. An acceptance test should be completed with results submitted to ARC for review and comment.

## REFERENCES

- ÖNORM F 3007: *Oxygen reduction system* (Austria)
- EN 16750:2017 – *Fixed firefighting systems – Oxygen reduction systems. Design, installation, planning and maintenance* (Europe)
- INRS ED 6126: *Working in a low oxygen atmosphere – Recommendations for the protection of the workers and prevention aspects* (France)
- CNPP EP 09-03 – *Study of the system efficiency of oxygen reduction prevention systems* (France)
- VdS 3527:2018 – *Oxygen Reduction Systems, Planning and Installation* (Germany)
- ISO 20338 (Draft International Standard) – *Oxygen reduction systems for fire prevention – Design, installation, planning and maintenance*
- BSI: PAS 95:2011 – *Hypoxic air fire prevention systems – Specification* (UK)
- BRL-K21017/01 – *The evaluation guidelines for the KIWA product certificate for design, installation, delivery, and support for inerting and oxygen reduction systems.* (Netherlands)

## QUESTIONS OR COMMENTS?

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**Tech Talk** is a technical document developed by ARC to assist our clients in property loss prevention. ARC has an extensive global network of more than 100 property risk engineers that offers tailor made, customer focused risk engineering solutions.

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