Fire Protection Association

RISCAuthority

OXYGEN REDUCTION SYSTEMS

This document has been produced by the RISCAuthority Active Suppression & Detection working group to provide information and outline guidance on the application of Oxygen Reduction Systems (ORS).

What is an Oxygen Reduction System?

Oxygen Reduction Systems are a form of fire protection that seeks to prevent the ignition of materials by maintaining a permanently depressed oxygen concentration within the protected space that they reside. In this sense they are neither suppression nor extinguishing systems but may be considered a form of 'inerting' system.

The oxygen concentration should be below the lowest value at which any material in the protected space can be ignited . This 'ignition threshold' is a parameter derived from a test procedure specific in ORS standards that describes the % oxygen that will prevent ignition of a specific material arrangement from the experimental ignition source.

With key applications in data centres and warehousing - both occupied environments - the lowest oxygen value used is typically around 15%. In terms of the 'fire triangle', the lower the oxygen content, the greater the heat (ignition strength) required to initiate and sustain ignition and hence a lowering of the probability of fire starting.

How it works

Oxygen Reduction Systems use devices to separate air into its primary constituent components of oxygen and nitrogen, and reintroducing the nitrogen rich, oxygen lowered, stream back into the protected space.

A number of technologies may be used to achieve this including membrane separation and activated carbon absorption, with all methods operating on a continuous basis with function controlled by oxygen concentration sensors. Several modes of operation are also used to account for the different risk scenarios which might include:

1. Permanent reduction and holding at a reduce O_2%
2. O_2% reduction at two adjustable levels i.e. day/night
3. Permanent reduction with additional quick reduction from stored N_2 tanks on fire alarm signal
4. Two-stage quick reduction from ambient using stored N_2 in tanks upon pre-alarm, and confirmation, with subsequent maintenance by separators.

The key components of the system are air compressors, filters, nitrogen generators, central control unit, oxygen measuring sensors, notification and signalling devices, supply network, and N_2 storage tanks (if used).

Challenges and considerations

The principal challenges pertaining to ORS are the robustness of the 'ignition threshold' determination process, and the health and safety of personnel working in low oxygen atmospheres.

The ORS ignition threshold of a material is not an accepted material physical property in the same way that 'heat of combustion' is. It is a property based around a very specific test procedure outlined in *EN 16750 Fixed Fire Fighting Systems – Oxygen Reduction Systems – Design, Installation, Planning and Maintenance*.

There is concern that the test is very specific to a limited condition which may poorly replicate the majority situations that arise in real-world, real-scale scenarios, and may favour the delivery of high oxygen threshold results in comparison to other methods such as Limiting Oxygen Concentration (LOC). The principal concerns around the ORS ignition threshold test are that it uses a simple pre-mixed flame, of high momentum, that can blow out diffusion flames, and has very little radiative component.

With reference again to the fire triangle, just as the lowering of oxygen increases the amount of heat required for combustion, the use of low heat ignition sources increases the oxygen ignition threshold above what it might be for a more energetic source. Realistic sources of ignition might include hot surfaces (exhaust manifolds), electrical arcing, friction from failing rotating equipment, introduced liquid fuels (arson), battery failures, and many other forms besides.

In an ideal world the test ignition source would be of a magnitude sufficient to derive a concentration suitable for the confident protection of most common material risks, at scale, and for all material combinations with safety factor. A comparison or ignition threshold and LOC values for the important warehouse materials of cardboard and polythene are as follows:

	IT	LOC
Cardboard	15% O_2	12.86% O_2
Polythene	16% O_2	11.39% O_2

The possible difference being the externally applied additional heat to the LOC test.

In respect of health and safety, 15% O_2 represents the lowest limit that may be considered safe for occupation by healthy, fit individuals. However, prior to entry into such environments, risk assessments should be performed to cover: the working environment; the work and tasks undertaken; and the worker. Occupational health assessments should be in place for all workers who have a potential requirement to enter these atmospheres. Careful consideration should be given to: workers carrying out tasks that require higher levels of physical activity; smokers; and pregnant workers.

Applicable standards

VdS 3527 *Oxygen Reduction Systems Planning and Installation*

EN 16750 *Fixed Firefighting Systems - Oxygen Reduction Systems - Design, Installation, Planning and Maintenance*

PAS 95 *Hypoxic Air Fire Prevention Systems*

NFPA report *Review of Oxygen Reduction Systems for Warehouse Storage Applications*, 2018

Effective for use (subject to correct IT) with:

- data centres
- warehouses
- archives
- deep freeze storage areas.

Has limitations in relation to:

- where the stored materials are unknown (postal depots/ baggage handling)
- where introduced materials (arson accelerants and cleaning fluids), electric systems, or machine processes may provide an ignition source of greater energy than the ORS IT test
- buildings that are leaky/cannot be made gas tight, or where movement of commodity critically impacts ability to retain the low oxygen atmosphere
- maintenance of the system that takes the ORS offline
- external fires
- actions that may breach building boundaries such as explosion and vehicle impacts
- where packaging contains its own (normal) air supply
- chemicals capable of rapid oxidation in the absence of air
- chemicals capable of undergoing autothermal decomposition
- where air conditioning and openings cannot be closed/shut down on detection
- where sustained sources of ignition cannot be isolated or controlled on detection of fire
- Power outage remains a threat if backups fail.

Image courtesy FirePASS

Approvals

Vds

Best practice

System design and installation should be undertaken by accredited contractors knowledgeable in the function of the system and the many factors that can impact performance. Critical to good ORS design is the correct and robust establishment of the design oxygen concentration.

Best practice dictates the technology is most suited for use in new projects where the building may be designed and constructed to maximise the retention of the low oxygen atmosphere. Experience indicates that retrofit to leaky warehouses can fail due to an inability to reach the required oxygen concentration, or the high financial cost of electricity required to maintain the design concentration.

Ideally ORS would be used in normally unoccupied areas as this would allow greater freedoms to have atmospheres lower than 15% which would extend coverage to a greater range of materials and energy of ignition source, and have alternative measures in place to assure fire safety during times of occupation, or use one of the other previously described operational modes (3 and 4) that might drop concentrations rapidly using stored nitrogen supplies following successful evacuation.

All systems must be accompanied by a feasibility study to validate all potential consequences with respect to the health and safety of personnel in all foreseeable situations (i.e. permanent workplace, maintenance work, emergency response etc.), and administrative requirements (i.e. legal, workers' rights, liability insurance etc.) must be evaluated. Note that compromising on design oxygen concentrations for life safety reasons is not an acceptable option.

The overall fire protection strategy should combine ORS with active fire protection, very early warning fire detection, manual firefighting supported by an adequate fire water supply, and fire resilient construction. For example, sorting areas for warehouses should normally be sprinkler protected, irrespective of whether the warehouse has ORS protection or not.

Best use of HFC-125

'Asset protection' – ORS is an inerting system for use in business-critical areas to protect specific assets from fire damage.

'Life safety' – Not installed for life safety.

Property protection' – Can protect property from internal fire challenges only.

Environmental credentials

ORS has 0 ozone depleting potential and contributes to global warming through its power usage.