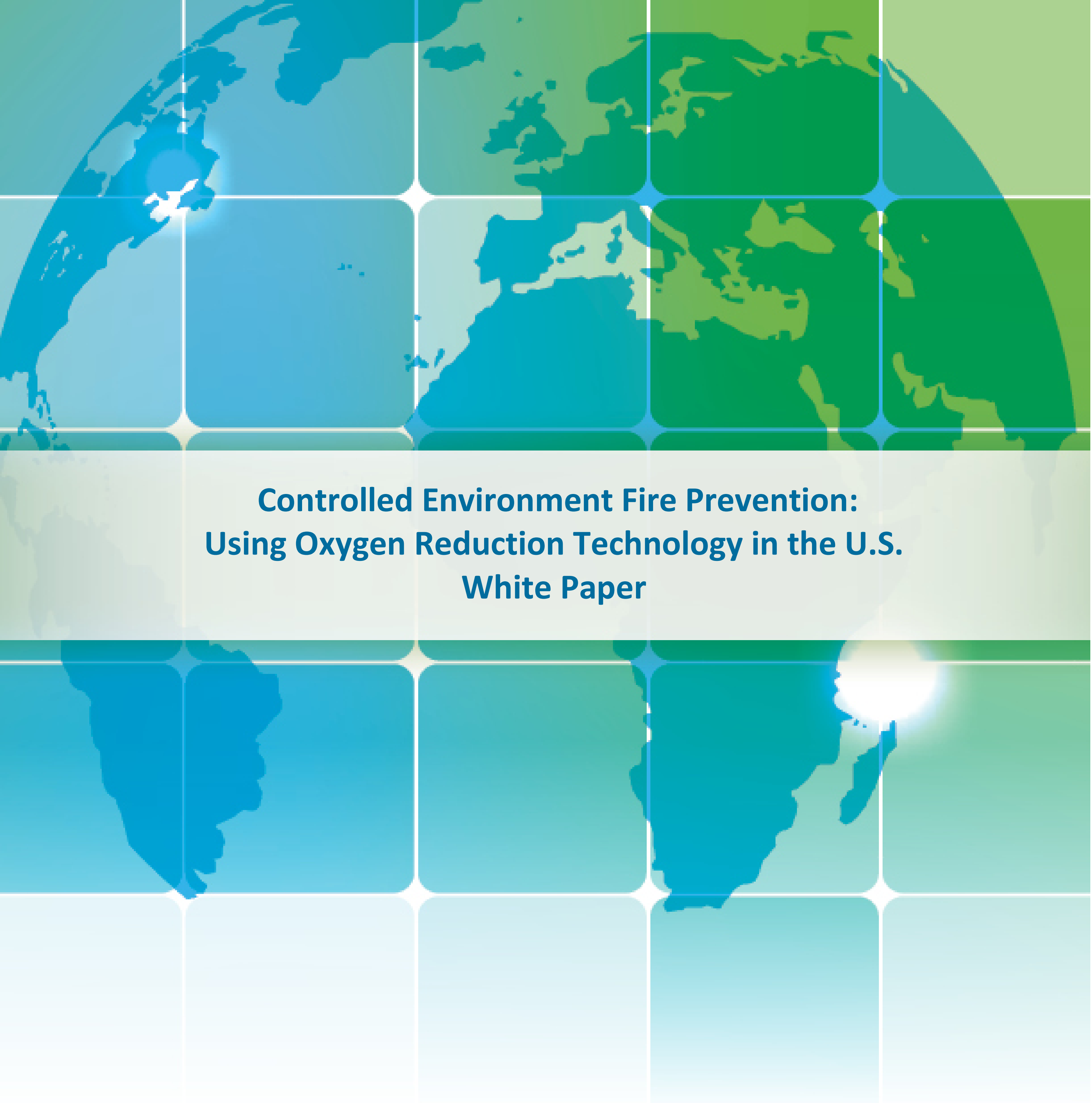


Controlled Environment Fire Prevention: Using Oxygen Reduction Technology in the U.S. White Paper

International Association for Cold Storage Construction

By Don Wiginton and Peter Clauss

For the International Association for Cold Storage Construction

Table of Contents

Background

At the 2011 Global Cold Chain Alliance Assembly of Committees, held in August 2011 in Washington, D.C. a subcommittee to the IACSC-IARW Construction/Codes Committee was formed to study a novel concept of reducing the concentration of oxygen within a controlled environment to a degree that life sustaining oxygen was lowered just enough to prevent fire from starting or spreading while continuing to support human life.

The concept of using oxygen reduction technology for fire prevention had already been successfully implemented in Europe for a number of years. In fact, members of the IARW and IACSC had visited a number of sites in Europe utilizing the technology. They reported that while walking through the facilities, they felt fine experienced no adverse effects during or after the visit. Many of the members wondered why this technology was not being used in the United States.

To help address their questions, the Construction/Codes Committee formed a subcommittee with the following mission:

1. Become informed on this alternative fire protection concept and learn how it works.
2. Determine the viability of utilizing the concept in the USA and identify the obstacles, if any, for implementation; and
3. Analyze the costs involved in comparison to the traditional fire sprinkler system generally required by building codes.

The subcommittee consisted of:

- Donald Wiginton, CEO of Wiginton Fire Systems
- Fred Walker, Senior Vice President of Engineering, Americold Logistics
- Scott Griffin, President, Griffco Design Build, Inc.

A first draft of the committee's findings was produced and presented at the November 2011 conference in Las Vegas by Don Wiginton and Scott Griffin.

During a subsequent meeting in Washington in August 2012, it was decided that a white paper should be developed and published for our members. Due to extenuating circumstances, some subcommittee members resigned while new volunteers were assigned. The new 2012 roster included:

- Donald Wiginton, CEO of Wiginton Fire Systems
- Jim Romine, Senior Director, Engineering, Lineage - East Coast Administration
- Scott Griffin, President, Griffco Design Build, Inc.
- Darrin Sealover, Vice President of Graycor Construction

The subcommittee developed the following white paper to capture their findings.

In November 2012 at the IACSC Conference & Expo in Orlando, our master committee decided to ask our European counterparts to take a look at our research and help us fulfill our mission properly. After receiving some invaluable input, the authors decided it best to re-write the white paper from scratch.

The paper was rewritten and reviewed by the Construction/Codes Committee in late 2013.

Note: This white paper is not intended to be the "final word" on this subject. As processes and technologies change, IACSC and IARW intend to revise this white paper as the industry changes. Members are encouraged to submit comments for consideration on the white paper at any point. Comments may be sent email@iacsc.org.

Acknowledgements

IACSC and IARW would like to acknowledge and thank all the members, listed above, who served on the subcommittee and contributed to this whitepaper.

The associations would also like to thank René Baartmans with B-Built BV, a design/build firm based in the Netherlands and Gary Koltiar of Fire Pass Corporation of Germany for their review and input into the white paper with particular appreciation expressed to Peter Clauss of Wagner Group, GmbH for the time and energy he spent in clarifying our understanding of the science and how it is being implemented in Europe and developing internationally.

Health and Safety

Those of us that have been at higher elevations have noticed that the air was "thinner."

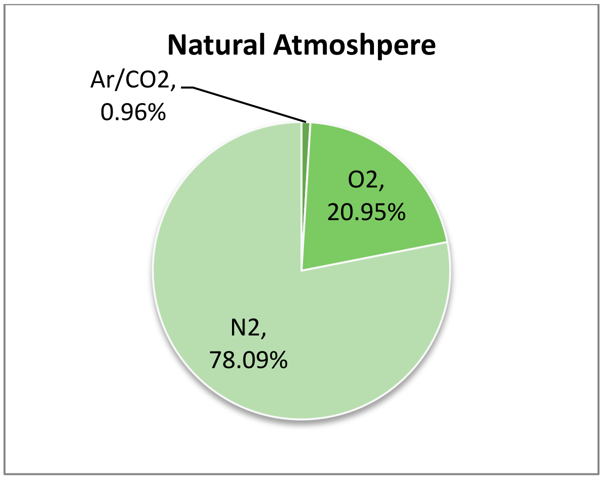
At sea level the oxygen content is about 21 Vol.- % and at 14,000 ft. it is still 21 Vol - %, but it is thinner and is equivalent to12 Vol.- % after factoring in the lower atmospheric pressure and the actual number of molecules available to breathe at 14,000 ft.

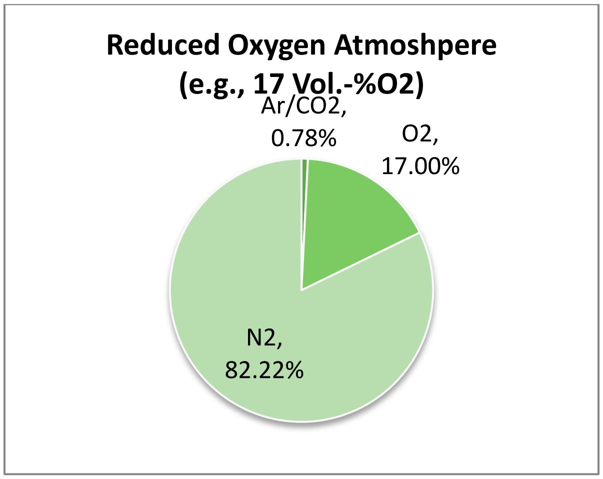
In normal surroundings, people do not use all of the oxygen molecules they inhale with each breath. How much oxygen one needs depends on a variety of factors including their level of exertion, physical condition and time needed to acclimate. There are a multitude of people, all over the world, conditioned to high altitudes, who could run a race at the reduced oxygen levels. These people have higher hemoglobin concentrations in their blood, and can extract oxygen more efficiently from the air they are breathing. Conversely, there are others that would be best suited to not subject themselves to a lowered oxygen environment.

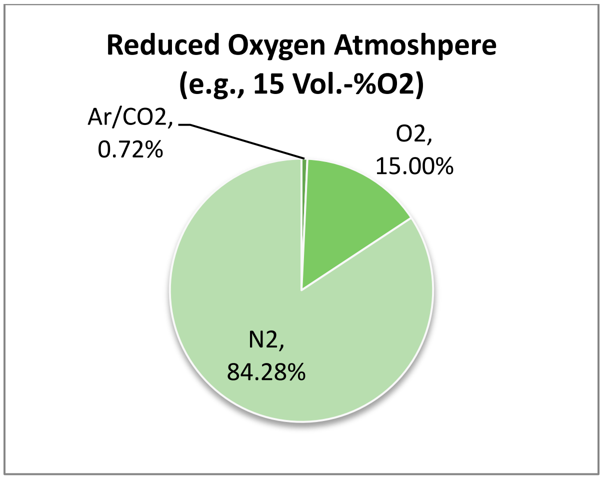
Numerous long-term studies have been conducted in Europe, including by medical professionals the University of Munich in Germany and the Union International Des Association D'Alinisme of Switzerland. These studies indicated that limited exposure to lower oxygen environments can be safely managed without causing undue risk to healthy human beings, using reasonable prudence in safety.

Indeed, several industries have proven that workers are able to function in reduced oxygen environments. Reduced oxygen is not a concern at ski resorts where lift operators and security personal work at elevations well above 10,000 feet and have acclimated to the thin air. Nor is there much concern for passenger and crew safety riding and operating aircraft with controlled reduced oxygen environments somewhere in the range of 16%.

Currently, in the United States, Occupational Safety and Health Administration (OSHA) regulations create the largest obstacle to any implementation to the "Thin Air" Fire Protection concept by not permitting work in environments with oxygen less than 19.5 Vol.-%, without wearing full face mask self-contained breathing apparatuses.







In contrast to OSHA regulations in the U.S., Europe's less restrictive regulations allow limited exposure for four hours at a time in environments with oxygen content between 15 Vol.- % and 17 Vol.- % and two hours at a time in environments with oxygen content between 13 Vol.- % to 15% Vol.- %, requiring a 30 minute rest break in between exposures, as well as physical examinations before entry along with repeat examinations every 2 years. If any difficulties are experienced, such as acute mountain sickness (AMS) the individual must leave the environment immediately.

Controlled Environment Fire Prevention Principles

Fire is a chemical reaction that requires three things to sustain itself - fuel, heat and oxygen.

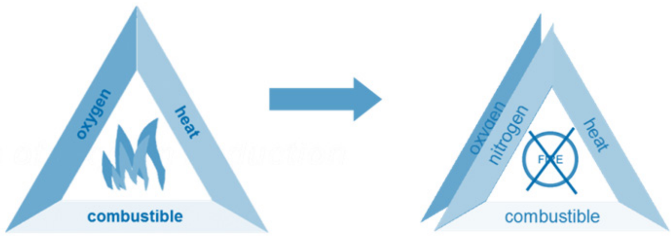
Oxygen is one of the fundamental components required for combustion (fire) to occur.

Too much O2 (rich environment) or too little O2 (lean environment) oxygen, and fire/combustion will not occur or sustain itself.

The pioneers of "thin air" fire prevention systems claim they can safely prevent unwanted fire from occurring or propagating all together within a controlled environment by breaking down the well known "fire triangle" through reducing the concentration of oxygen in the controlled environment.

Depending on the combustibility of the fuels and the temperatures being maintained, life sustaining oxygen can be calibrated and maintained below its normal pressurized 21% oxygen by volume (Vol.-%) at sea level to lower percentages by volume, each having an equivalent molecule concentration, corresponding to various higher elevations.

This controlled environment fire prevention concept is basically just another form of air conditioning. Systems are not designed to make the air cooler. They are designed to make the air thinner (reducing oxygen) and in doing so, fire is prevented from starting or spreading. "Thin air" fire protection systems are quite different from all other forms of fire protection as it is proactive and constantly maintained to prevent the chemical reaction of "fire" to occur at all. Other fire protection systems such as fire sprinklers or gaseous agent systems are reactive in nature. However, what both forms of fire protection have in common, is their basic function of interrupting one or more of the three essential elements (fuel, heat and oxygen) of the chemical reaction known as fire.



To what degree the oxygen needs to be lowered to prevent fire depends on the other two legs of the "three legged" stool. The temperature the controlled environment will be maintained at and the combustibility and other characteristics of the products occupying the space must be taken into account. Since it is proactive in nature and not required to penetrate and extinguish a raging fire that has somehow broken out, the methods and heights for storing materials becomes irrelevant.

How it Works

The main system components are:

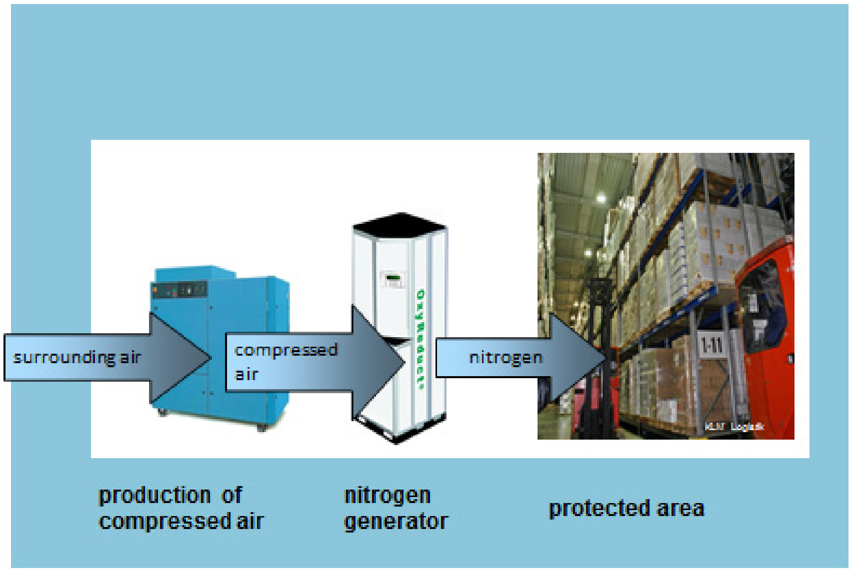
- Relatively air tight environment
- Nitrogen production generator,
- N_2 distribution piping/network, and
- System controls and monitoring

Air-Tight Environment

We must first begin with a controlled air-tight environment. A "thin air" fire prevention system is dependent on maintaining an air-tight environment and keeping the entire space at a constant oxygen concentration level. To maintain the controlled environment, airlocks or vestibules may be used between freezers and shipping docks.

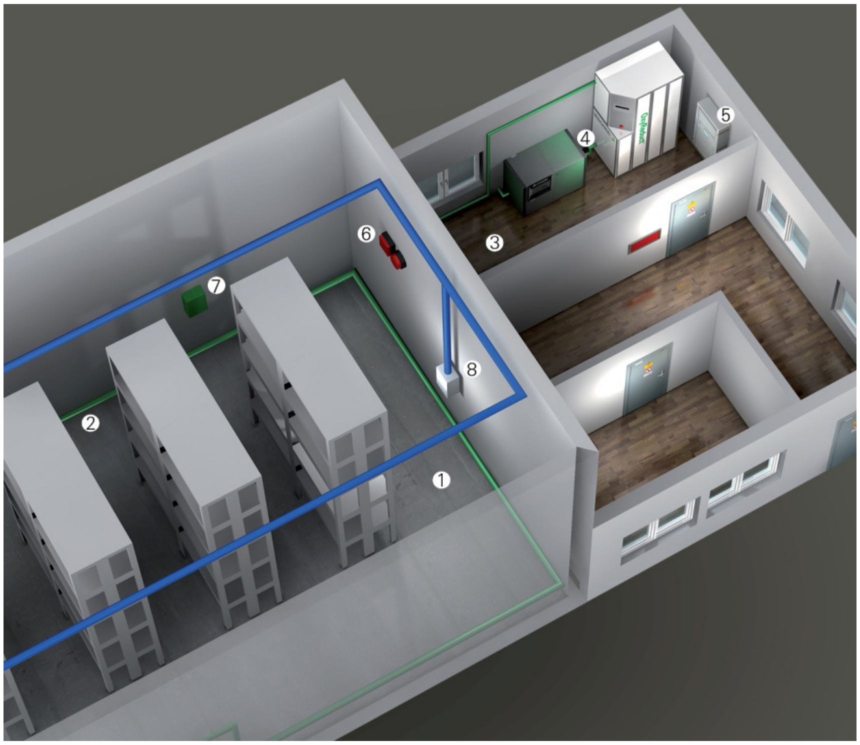
Oxygen Reduction through Nitrogen Production

Natural ambient air is compressed by a standard industrial air compressor. The compressed air is cooled, filtered, and fed to a nitrogen generator. In the nitrogen generator, the nitrogen and oxygen are separated by a membrane filtration system. This results in 95% pure N_2 for distribution/injection into the protected "thin air" environment. The separated O_2 is vented to the outdoors.



Nitrogen Distribution

The 95% pure nitrogen is distributed into the freezer warehouse, via the freezer evaporator fan ductwork and discharge grills. The N_2 is thoroughly mixed with the conditioned air, and is diffused throughout the warehouse.



Key:

1. Protected area
2. Nitrogen input piece
3. Operating room
4. Nitrogen generation
5. Control panel
6. Alarm
7. Oxygen sensor
8. Air sampling smoke detection system

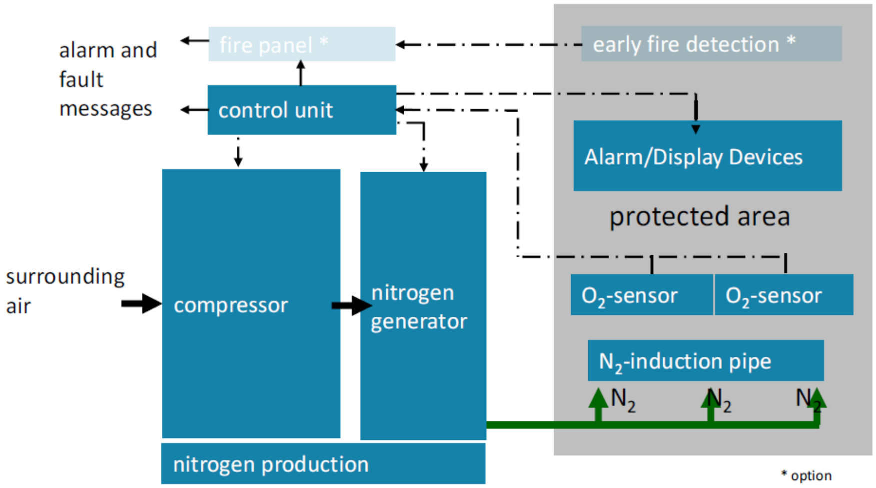
Controls and Monitoring

The oxygen reduced air is maintained through oxygen detectors/monitors distributed throughout the freezer. The system is controlled through a dedicated control system, constantly monitors the concentration of O_2 in the protected area and generates and injects additional N_2 on as-needed basis. The system is able to control the O_2 concentrations levels within ±0.2%.

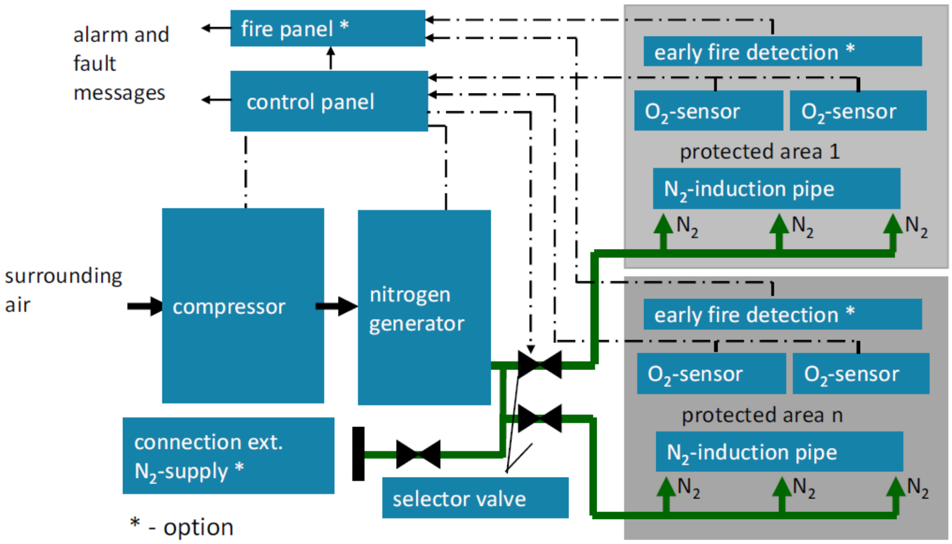
The reduced oxygen concentration is established during initial building/room commissioning and is continuously maintained during building use and occupancy. Thus, a fire-proof environment is always provided.

A general system layout of the proposed single zone system is illustrated as follows:

System sketch for single zone system



System sketch for a multi zone system



Installation Guidelines and Standards

There are a number of European companies involved in marketing and developing this means of fire prevention.

Currently, there is no guideline, standard or avenue for design, installation, or maintenance of Reduced Oxygen Fire Prevention Systems in the United States. However there are several different European guides available as listed below:

- VdS 3527 en, VdS guidelines for Inerting and Oxygen Reduction Systems (Germany)
- TRVB S 155 and ÖNORM F 3007 (Austria)
- SN 123456 (Switzerland)
- PAS 95 (United Kingdom, November 2011)
- CEN/TC 191, which has been in progress since 2011.

CEN (Central European Norm) Standard is under development (CEN/TC 191 TC 191 WI 00191236) and will be the primary unified standard for all of Europe. As of publication, the final version is expected to be available in the second or third quarter of 2013. This standard lays out most of the consideration related to design, installation, planning, maintenance and public safety precautions. In Viability of "Thin Air" Fire Prevention in the USA

Building Codes and Standards

Buildings constructed in the United States generally require adherence to one of the major model building codes, typically either the International Code Council (ICC), the International Building Code (IBC), the International Residential Code, the International Fire Code, the International Energy Conservation Code, the International Plumbing Code, the International Mechanical Code and others.

These codes call for fire protection to be provided at various hazard classifications and size thresholds that comply with the National Fire Protection Association standards.

Typically, the standard for public refrigerated warehouses is NFPA #13 Installation of Fire Sprinkler Systems.

Within the NFPA #13 standard, there is a statement which reads:

> "Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered."

Could that statement be relied upon to support the adoption of Reduced Oxygen Fire Prevention Systems as a satisfactory alternative to a fire sprinkler system?

Oxygen reduction fire prevention systems have been approved and in use, predominantly in Europe, for more than 15 years. Currently there are over 700 system installations in more than 20 countries. The installed systems have country wide acceptance in 10 countries, with approximately 600 installations in these countries. In the remaining 10 countries, the 100 system installations have been approved by the local authorities on a case-by-case basis

OSHA

The other big hurdle to implementation in the USA has a lot to do with OSHA's willingness to reconsider their Respiratory Protection Standard, which requires that anytime someone enters a space containing less than 19.5% he/she must be wearing a full face mask self contained breathing apparatus.

Insurance Underwriters

Each company would need to speak with their risk management provider to make sure that are insurable and comfortable with the potential liabilities involved.

Practical Applications

Since it is essential to control the environment, Reduced Oxygen Fire Prevention Systems would present a challenge to the typical PRW warehouse which experiences excessive air infiltration caused by doors being regularly open and closed during operations. Some have overcome this challenge by going fully automated using airlocks and vestibules to keep the "thin air" from escaping.

Cost Considerations

One estimating exercise was accomplished by the committee, using a small ASRS (automated storage retrieval system) in the North East as the sample project. Our findings put the cost of both systems very close together with conventional fire sprinklers costing a little bit less. Our friends in Europe claim the Reduced Oxygen Fire Prevention Systems on typical projects tend to cost significantly less than fire sprinkler systems. The ongoing energy costs and maintenance costs are significantly higher but not prohibitively. The bigger the project, the bigger the differential on both installation and operating costs.

Conclusion

In Europe, Reduced Oxygen Fire Prevention Systems have already been enthusiastically accepted by users and public safety officials. If it really works and if it really doesn't cause any serious occupational worker hazards, it would seem only logical that this new form of fire prevention would eventually become accepted in the USA. As with anything new it may take a little bit of time and effort.

Resources

For more information, please consult the following resources.

Torres, Katherine. "OSHA Rejects Fire Prevention Technology." *EHS Today Home Page*. EHS Today, 28 May 2008. Web. 25 Jan. 2013.

Chiti, Stefano (November 9, 2011). "A Pilot Study on Hypoxic Air Performance at the Interface of Fire Prevention and Fire Suppression". *FIRESEAT 2011: The Science of Suppression*.

"PAS 95:2011 Hypoxic air fire prevention systems. Specification". BSI.

EUSAS Journal No 5 April 2009 "Permanent Fire Prevention with Oxygen Reduction - Technology and Applications"

Work in Hypoxic Conditions-Consensus Statement of the Medical Commission of the Union Internationale des Associations d'Alpinisme (UIAA MedCom)

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