Safety Information

Prepared by the Safety Advisory Council Safety Info 29/21

Oxygen Deficiency Hazard associated with Hypoxic Fire Suppression Systems Using Nitrogen Injection

Introduction

This information sheet applies to Hypoxic Fire Suppression Systems using nitrogen injection to generate and maintain the atmosphere for their stated purposes.

EIGA is concerned that sufficient guidance is provided on the hazard to people in relation to oxygen deficient atmospheres, the importance of control systems to provide a safe atmosphere and also the health assessment and related controls required to ensure people occupying these spaces are safe.

Manufacturers of oxygen reduction systems and/or nitrogen suppliers should ensure that their own organisations as well as their customers are aware of this Safety Information sheet and the EIGA documents referenced on asphyxiation risks and the hazards of inert gases, to determine and implement safety measures in accordance with the related standards (EN 54-7 *Fire detection and fire alarm systems. Smoke detectors. Point smoke detectors that operate using scattered light, transmitted light or ionization*, EN 50104 *Electrical equipment for the detection and measurement of oxygen. Performance requirements and test methods*, EN 16750 *Fixed firefighting systems. Oxygen reduction systems. Design, installation, planning and maintenance, and specific local standards*) [1, 2, 3].

This information sheet is intended to raise awareness of the asphyxiation risks associated with these systems and does not address the question of fire suppression effectiveness of these systems, the accuracy of claims made correlating the physiological effects on people between living at high elevations or during commercial air travel and occupying spaces where hypoxic fire suppression systems are in operation, or other aspects of the design, installation, operation and maintenance of these systems.

What are Hypoxic Fire Suppression Systems?

Hypoxic Fire Suppression Systems are designed to create a permanent normobaric hypoxic atmosphere, under which conditions common materials cannot ignite or burn due to lack of oxygen. Hypoxic means that the partial pressure of the oxygen is lower than that at sea level. Normobaric means that the barometric pressure is equal to the barometric pressure at sea level.

In practice, these systems are designed so that the atmosphere in these environments contains approximately 15% oxygen and 85% nitrogen by volume. The displacement of oxygen can be achieved through the injection of nitrogen.

Nitrogen is a naturally occurring gas which represents approximately 78% of the volume of the earth's atmosphere and hence the air we breathe. The other major component of the air we breathe is oxygen at approximately 20.8% by volume.

Risks associated with Hypoxic Fire Suppression Systems using Nitrogen injection systems

Atmospheres where oxygen is depleted shall be treated as hazardous and precautions need to be taken to avoid harm to people. Oxygen deficiency is a significant physiological hazard for humans because:

- the low oxygen concentrations could endanger the life of the occupants due to the risk of asphyxiation. It is not unusual for the person suffering from asphyxia to be totally unaware of the symptoms and they may even feel euphoric. It can take as little as two breaths in an oxygen deficient atmosphere to cause unconsciousness and death can occur within minutes;
- the effects experienced by individuals at different concentrations, is subject to their personal sensitivity (e.g. health, fitness levels) and task factors (e.g. time available to acclimatise, intensity of effort). The more abruptly

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an environment becomes hypoxic, the more frequent and significant the symptoms may be (Falcy 2012);

- exposure to a reduced partial pressure of oxygen decreases the body's performance through increasing fatigue, error rate and reaction time, and is hard to compare with higher altitude exposures (where there is also reduced partial pressure of oxygen) as there is no adaptation phase and repeated variations (e.g. entering/exiting the facility) (Falcy 2012).

Table 1 gives guidance on the typical effects that should be expected in oxygen deficient atmospheres:

Table 1—Effects at various oxygen breathing levels

Oxygen percent at sea level (atmospheric pressure = 760 mmHg)	Effects
20.9	Normal (below 19.5% is considered oxygen deficient)
19.5 – 10	Increased breathing rates; accelerated heartbeat; and impaired attention, thinking, and coordination
10 – 6	Nausea, vomiting, lethargic movements, and perhaps unconsciousness
<6	Convulsions, then cessation of breathing, followed by cardiac standstill (death). These symptoms can occur immediately.

NOTES

1 Adapted from Title 29 of the U.S. *Code of Federal Regulations*, Parts 1910 and 1926 [4].

2 These indications are for a healthy average person at rest. Factors such as individual health (being a smoker), degree of physical exertion, and high altitudes can affect these symptoms and the oxygen levels at which they occur.

3 A hazardous atmosphere oxygen concentration range as defined by OSHA is outside the range of 19,5% and 23,5% [4].

4 While the percentage of oxygen does not change with altitude, the partial pressure of the atmosphere decreases, which creates physiological effects similar to oxygen deficiency. These effects increase at higher altitudes. Working at altitudes above 2 438 m (8 000 ft) can have similar effects to working in a 15% oxygen atmosphere and working at altitudes of 4 267 m (14 000 ft) can have effects similar to a 12% oxygen atmosphere. Precautions such as supplemental oxygen and acclimatisation shall be taken when working at altitudes to protect the employees against the effects of altitude sickness and other physiological effects similar to those experienced with decreasing oxygen concentrations. Consult knowledgeable medical and safety professionals regarding the specific precautions to take when working at high altitudes.

Nitrogen is not classified as hazardous to health, but is an asphyxiant in high concentrations by displacing oxygen.

The hazard of oxygen deficiency requires the implementation of controls to reduce the health and safety risks for occupants in areas protected by hypoxic fire suppression systems in agreement with the risk assessment.

Hazard Considerations and Concerns with Hypoxic Fire Suppression Systems

EIGA does not recommend occupancy of atmospheres containing less than 19.5% oxygen without ensuring controls are in place to avoid adverse health impacts.

Recommendations for Safe Operations

EIGA recommends the following guidelines considerations for the safe operation of hypoxic fire suppression systems:

- Assess whether the requirement for personnel to enter areas of reduced oxygen concentration can be eliminated, and if not, whether the duration or number of people can be reduced.
- Comprehensive health assessments of personnel entering and occupying hypoxic environments shall be completed. These assessments need to consider the activity levels of each individual during the course of each occupancy, and have suitable follow-up assessment(s).
- Constant monitoring and display of oxygen concentration.
- Effective access control for authorised persons.
- The nitrogen injection system shall be designed to ensure there are not pockets or periods of oxygen deficiency beyond design parameters without proper additional controls. All critical control systems shall be subject to formal risk assessment, e.g. SIL determination of Safety Instrumented Systems.
- Any engineering controls shall be designed, installed, maintained and operated by personnel trained and

qualified in the operation of the equipment.

- Supervisory personnel shall be trained in the operation of the equipment and in the hazards of oxygen deficiency.
- Emergency procedures shall be in place and regularly practiced (including lone worker and 'man-down' systems), and emergency equipment (such as breathing apparatus) shall be readily available and maintained in working order.

References

[1] EN 54-7, *Fire detection and fire alarm systems. Smoke detectors. Point smoke detectors that operate using scattered light, transmitted light or ionization,* www.cen.eu

[2] EN 50104, *Electrical equipment for the detection and measurement of oxygen. Performance requirements and test methods,* www.cen.eu

[3] EN 16750, *Fixed firefighting systems. Oxygen reduction systems. Design, installation, planning and maintenance,* www.cen.eu.

[4] *Code of Federal Regulations,* Title 29 (Labor), Government Printing Office. www.gpo.gov

[5] Doc 44, *Hazards of Oxygen-deficient Atmospheres,* www.eiga.eu

[6] Falcy, Dr M, 2012, *Working in low oxygen-controlled atmospheres – risks and prevention measures* (Institut National de Recherche et de Sécurité)

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