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Clearing the air

Jensen Geir explains how hypoxic air venting systems are protecting buildings

AN HYPOXIC air venting (HAV) system is a new form of fire prevention technology that works by conditioning air. It controls both the relative levels of oxygen and nitrogen to create a 'fire proof' but breathable atmosphere so that people can safely occupy the space, but nothing within it can ignite or burn. It can also control temperature and humidity in a room to provide optimum conditions for the storage of items and people's comfort.

The basic design concept of a HAV system involves generator units being fitted into plant rooms adjacent to, or inside, the rooms being protected. The generators pre-mix hypoxic air for injection either into recirculation ducts or directly into the protected rooms. The system then establishes the most uniform atmosphere possible (at a predetermined oxygen level) and, if the space is occupied, continuously vents it with fire-safe but breathable air.

Several companies worldwide provide these systems, all of which comply with a patented technique by license agreement with a US company – FirePASS Corporation. The patent relates to breathable hypoxic air being generated, rather than it being created in the protected space by injecting potential hazardous levels of inert gases into the air.

The technology itself does not require the use of obtrusive pipes and nozzles in the protected space, nor any detection and actuator systems (as required by extinguishing systems). In addition, when the system is turned off, its fire prevention capability continues for several hours.

Concentration levels

Hypoxic (inert) air comprises 'normal' air (a mixture of oxygen, nitrogen and small quantities of other elements) that has had the relative concentrations of its constituent elements altered to reduce its oxygen content. Typically, in hypoxic air systems, only 5% to 6% of the oxygen content is removed and nothing is added.

When produced via a HAV system (to give closely controlled predetermined oxygen concentrations), an atmosphere can be maintained with enough oxygen to enable humans to breathe normally, but with insufficient oxygen for common materials to ignite or burn. Figure 1 illustrates the change to air composition brought about by a HAV system, while Figure 2 shows that HAV systems produce oxygen concentrations equivalent to genuine altitude air, while still having the same density (pressure) as air at sea level. With regards to the human body, HAV air is equivalent to living at altitude, or

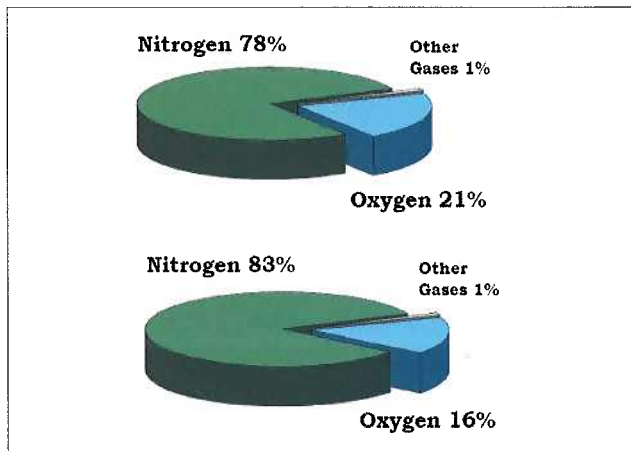


Figure 1: Normal air (top) versus hypoxic air (bottom)

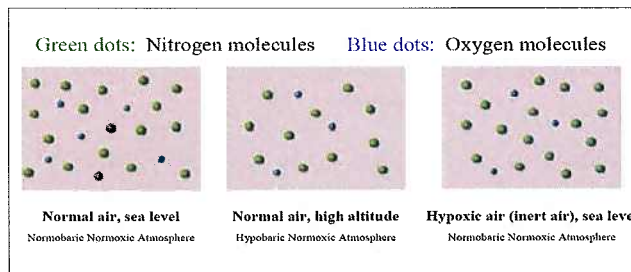


Figure 2: Comparison of inert air at sea level and mountain summits

flying on an aeroplane (where cabin pressure is adjusted to provide similar oxygen concentrations to HAV air).

As Figure 3 shows, the human respiratory system is hardly affected by oxygen concentration levels of 15% to 21% and easily tolerates 12% concentration levels. Unlike in actual altitude air, the increased number of nitrogen molecules relative to oxygen molecules in HAV air, blocks the combustion process from accessing those oxygen molecules, effectively acting as a 'fire blanket' around the molecules. The human respiratory system is hardly affected but the combustion process is prevented.

Safe atmosphere

The air produced by a HAV system can have added health benefits, as well as enabling people to occupy a HAV area for extended periods of time. For example, people who experience high altitudes, such as those living in Mexico City or those flying at altitude, are subjected to precisely the same amount of oxygen as those occupying an area with hypoxic air. The human body is created to perform well in air containing 15% to 21% of oxygen, and several studies show positive benefits, such as respiratory improvements. A report on intermittent hypoxic therapy by the Hypoxia Medical Academy Clinical Research Laboratory in Switzerland, for instance, shows that most people become healthier from lowered oxygen levels. Indeed, many world-class athletes train using HAV environments to improve performance.

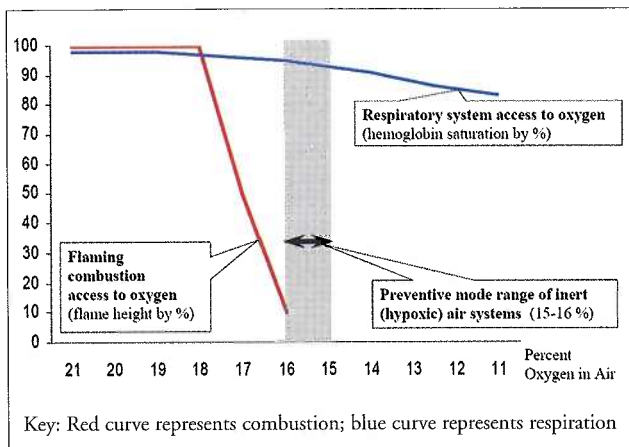


Figure 3: Effects on the human respiratory system of oxygen concentration in air used for human occupation

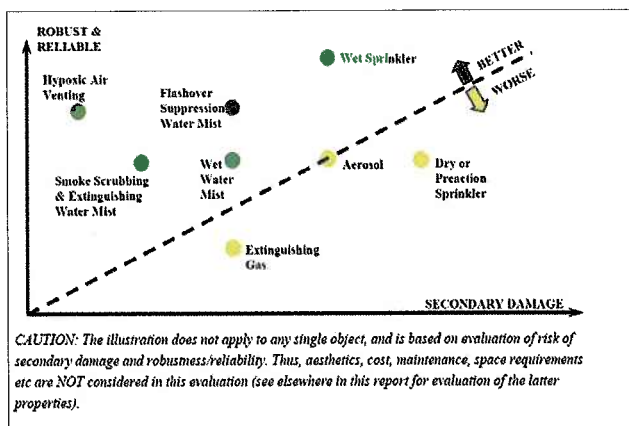


Figure 4: A qualitative comparison of two vital properties of fire protection systems for heritage

However, it should be noted that individuals with illnesses preventing them from being at high altitudes should not occupy hypoxic air areas. In addition, although unlikely, low-oxygen atmospheres could develop potential health hazards for people who work in these environments for prolonged periods. Detailed health assessments of individuals in relation to the tasks required to be performed in these environments may be necessary.

As a result, public spaces fitted with HAV systems should be treated in the same way as aircraft cabins (where similar conditions pertain). Individuals with predispositions for disease in hypoxic air should either not be allowed to enter the area, or should spend only limited amounts of time there. However, since human respiration is unaffected by hypoxic air, there should be no reason for concern if artificial atmospheres are established for normally occupied rooms near sea level.

System application

With the exception of 24-hour inert gas systems, there has until now been a lack of conventional systems that reliably prevent a fire from occurring in a building. However, these inert systems, which typically feature high concentrations of nitrogen, are often not used because of the potential health hazards they pose; the requirement for breathing apparatus to be used when accessing the environment; and the level of cost involved.

For more than a decade, buildings such as large warehouses and freezer storage rooms have been installed with oxygen-reducing systems based on feeding pure nitrogen gas into rooms to provide hypoxic air that protects them from fire. This technology has had to take into account risks associated with suffocation (related to nitrogen inlets), inadequate mixing of the air and risks of the system failing.

Since the systematic design of HAV systems, however, system generators pre-mix hypoxic air for injection into recirculation ducts or directly into protected rooms, providing a fire-safe atmosphere that is safe for humans to breathe. As a result of this improved technology, HAV systems are proving to be popular installations in the telecoms, power and oil industries, and in the military.

Another area where HAV systems have been installed is in museums. In the past, museums have not favoured the use of extinguishing systems because of their obtrusive installations, the fact that considerable initial fire damage can occur before extinguishment, the risk of false alarms, and costly refilling operations. However, museums have used halocarbon or inert gas systems to protect delicate artefacts and archives.

It is also worth noting that, although the performance of competing fire protection technologies (such as water mist systems and fire protection fluid systems) have improved, these technologies – unlike HAV systems – still rely on detectors, actuators, power supplies, control panels and associated cabling to function correctly. In addition, regardless of how small a fire is, they do not prevent the damage caused by the spread, of harmful smoke and gas generated by a fire. Museums are now finding that HAV systems offer numerous benefits, not only in preventing ignition, initial smoke and fire spread, but also the added advantage that air produced by these systems reduces the rate at which artefacts decay.

A report for the European Cooperation in the field of Scientific and Technical Research (COST), Action C17: *Built Heritage: Fire loss to historic buildings*, compared most of the fire extinguishing and inert systems available. It addressed the key concerns of the heritage communities, namely, reliability and secondary damage. Hypoxic air venting came out a clear winner, despite this comparison being only qualitative (see Figure 4).

Benefits and drawbacks

HAV systems are the only systems to offer the prospect of fire prevention in both occupied and unoccupied areas. While inert gas and aerosol systems can provide fire suppression in unoccupied areas, once discharged, any rekindling due to accumulated heat would not be tackled. On-site generation with HAV means that agent is always available.

As explained previously, in HAV systems, the inert air is continuously generated on site and fed either to the building's air-conditioning system or its inlet air ducts (or by fully reversible mobile units located in the rooms). So, unlike gas extinguishing systems, there are no gas-filled tanks/reservoirs that run empty or require refilling.

In addition, hypoxic air venting has the potential to avoid invasive installations, both for single room and multiple room protection. Various design options allow for virtually no physical or aesthetic invasions. Pipes, nozzles or equipment in the protected rooms are generally not required or can be discreetly positioned, and no room fans, detection or activation systems are required. Most significantly, there is no risk of secondary damage, no environmental impact and reduced corrosive activity.

A challenge of implementing hypoxic air systems is to optimise energy cost, which depends strongly on air exchange rate and air leakage. Compressors must be located or encapsulated in such a way as to reduce noise. As with any inert gas extinguishing system, analysis must be carried out to ensure that any special substance which may burn at a low oxygen level is supported by other measures, or by incorporating an inert air 'suppression mode' option – that is, using inert air in the same way as inert gas or hydrocarbon gas for extinguishing.

Where inert air in 'prevention mode' (keeping HAV air in the room constantly) becomes impractical due to either access control of public areas or high energy consumption, inert air may be applied in suppression mode. In suppression mode, when prompted by a fire detection system, a storage tank of inert air is dumped on demand, at which point the HAV generator starts to provide a continuous supply to prevent secondary fires. The system then runs for continuous protection. However, the suppression mode may involve HAV air of lower oxygen concentration than the preventive mode, and people should evacuate – although it should be noted that even the HAV suppression air is still safe for most people for some of the time.

A HAV system for either prevention or suppression may not, by its inherent design, accidentally dump dangerous concentrations of nitrogen or other substances, since systems produce or store safe inert air and are designed to be failsafe. However, caution should be exercised when the volumes to be protected (whether a whole building or individual rooms) are less airtight, if the ventilation exchange rate has to be high, or if the areas to be protected are frequently accessed by opening doors without airlock provisions.

Further research is planned for the design of both special HAV applications and how to optimise designs, with some companies considering joint research ventures to research and develop applications to fit their industry. To preserve artefacts, research is being considered to investigate the hypoxic air effect on the degradation rate of artefacts by accelerated artificial ageing. In the future, it seems, the implementation of HAV technology will be even more widespread □

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