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RESEARCH REPORT

Hypoxic Air Venting for Protection of Heritage

by

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Cover illustration

Records in the Monte dei Paschi di Siena Bank, the most ancient bank in the world, founded in 1472.
Photo by Geir Jensen

RESEARCH REPORT

Hypoxic Air Venting for Protection of Heritage

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EXECUTIVE SUMMARY

A novel technique to protect heritage buildings and artefacts from fire and degradation has been evaluated.

Inert air, referred to as hypoxic air (reduced oxygen concentration), comprises slightly altered concentrations of components of air. Typically 5% of the oxygen content is substituted by nitrogen. Inert air has predetermined oxygen level and safely vents the space to be protected continuously. Inert air is safe to breathe, but prevents fire ignition in common materials. Inert air replaces the use of inert gases.

The exploration of inert air for fire protection is recent, and several milestones have been passed in quick succession over the past ten years. Three years ago, the concept of premixed hypoxic air feed into the protected room superseded the technique of nitrogen feed into the room until hypoxic air is established, and made the inert air option safer, simpler and less expensive. A rush of research and development for various applications are being made, such as vital rooms for telecommunication. The United States Federal Aviation Administration has proposed regulation to retrofit of all commercial airplanes with hypoxic ventilation for fuel tanks. The potential benefits to heritage are many.

Inert air is generated by simple and reliable units that fit into air conditioning plants, or mobile autonomous units are located in or at rooms to be protected.

Implementation issues on fire safety, health, cost, reliability, maintenance and impact on artefacts and fabrics have been evaluated. A list of hypotheses which stated potential benefits and drawbacks for heritage applications was analysed.

Fire protection of heritage has always been challenging. Fires do irreversible damage before they are extinguished and often firefighting agents cause secondary damage. Extinguishing equipment is often aesthetically obtrusive and may inflict damage to the building fabric or décor. Unintentional activations and routine maintenance may also damage artefacts, décor and fabric.

Inert air venting is found to be remarkably promising for heritage applications. Inert air prevents ignition, initial smoke and fire spread. Storage rooms, laboratories and exhibitions may be protected, with sizes ranging from small closets to large volumes. Public spaces could be treated in the same way as aircraft cabins where similar conditions pertain by not allowing individuals with predispositions for disease in hypoxic air to enter.

Pipes, nozzles or equipment in the protected rooms are generally not required. No room fans, room sensors, detection nor activation systems are required. The inert air is continuously generated on site, thus a minimum of space is required. Generators couple to the building air conditioning system or to inlet air ducts. Fully reversible mobile units may be located in the rooms. Unlike with gas extinguishing systems, no reservoirs run empty or require refilling.

It is shown that inert air venting has potential to avoid invasive installations. Both for single room and multiple room protection various designs allow for virtually no physical, aesthetic or irreversible invasions at all. There is virtually no risk of secondary damage, environmental or corrosive issues. The inert air may positively contribute to the diminishing of normal deterioration of organic and non organic objects as well as décor.

A challenge of implementing inert air systems is to optimize energy cost, which depends strongly on air exchange rate and air leakage. Compressors must be located or encapsulated to reduce noise. Analysis must be done to ensure that any special substance which may burn at low oxygen level are taken care of by other measures as with any inert gas extinguishing system, or by incorporating an inert air suppression-mode option.

Where inert air in prevention mode 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 a reservoir of inert air is dumped on demand, when prompted by fire detection; the system thereafter running for continuous protection. Suppression mode may involve inert air of lower oxygen concentration than the preventive mode, and people should evacuate - but the inert air is still safe to occupy for most people, even for extended periods.

Inert air venting systems for either prevention or suppression may not, by their inherent design, incidentally dump dangerous concentration of nitrogen or other substance. Systems produce or store safe inert air and fail-safe mode is pure air.

Some national code limits on oxygen level for confined enclosures in buildings may require special permit, or management measures such as control of staff or public areas to prevent access by individuals predisposed to heart disease etc.

In order to optimize inert air venting in the future, research should be done to further determine fire heat and smoke retarding effects, or damage per minute rates, in hypoxic air. Also, effects on smouldering fires should be investigated. Once cleared, there is a probability that the oxygen level may be increased further in some heritage applications.

Four case study examples demonstrate that a range of buildings may be well protected by properly designed continuous inert air systems. The Arezzo Public Library building and the Stenhouse building computer room offer moderate challenges in incorporating the installation. The Linné Building and the Arezzo Public Library building offer the most irreplaceable cultural values and should gain the most of benefits from inert air systems. The Trøndelag Folk Museum offers the least challenges and lends itself to cost-efficient installations.

More than 50 installations using inert air by the nitrogen feed principle are by now reported installed in Europe. Full coverage by the inert air venting principle is currently planned for two new public libraries in the Middle East.