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Fire protection in critical environments: Integrated fire safety solutions for archives and libraries

Archives and libraries contain valuable and often unique and irreplaceable documents which need to be preserved permanently for use by future generations. Fire is one of the most prevalent threats to archives and libraries. Integrated fire safety solutions, tailored to individual risk levels, regulations and customer circumstances are of vital importance for the protection of the irreplaceable documents.

Fires in archives and libraries have a devastating effect on the records, not only from damage caused by the fire itself, but also from consequential side-effects: smoke, gases, water and heat. Smoke gases leave a greasy, oily film on the valuable items which is very difficult to remove. Water used to extinguish the fire is often even more damaging. The fire in the Duchess Anna Amalia Library in Weimar (Germany) in 2004 for example caused a third of the complete damage and the other two-thirds were caused by water.

According to J. A. Wilson, Head of Fire Protection and Safety at the Smithsonian Institute in the United States, which brings together 19 museums and preserves over 137 million collections, fire is the most prevalent threat to cultural institutions. Property damaged by floods can often be dried out and restored. Structural damage from an earthquake might be repaired. Stolen property always has a chance of being recovered. Damage from fire, however, is usually permanent and irreparable. Fire makes no distinction between materials and can spread quickly through the different rooms of a building.

Fire load

A high concentration of combustible materials, limited space and constant air-conditioning, are some of the factors that increase the complexity of designing an integral fire safety concept. It is worth to mention that many archives do not only store paper documents, but so-called new storage media as well. These include photo-chemical storage media (negatives, slides, films, microfilms, etc.) and electronic data storage media (magnetic strips, DVDs, hard drives, solid-state

memories, flash memories, etc.), as well as print on non-organic materials (glass, plastic, etc.). The fire load in archives is demonstrably and inherently high due to the concentration of combustible items made of paper (books, manuscripts, pictures, maps), plant material (papyrus, palm leaves) or animal media (parchment), usually stored in cardboard boxes. Storage space in archives is highly valued and expensive, given that temperature and humidity are, in many cases, carefully regulated. It is recommended that antique forms of cotton paper (produced before 1830) should be kept at 20°C and 50% humidity, while wood-based paper with a high acid content (produced between 1830 and the start of the 20th century) should be kept at 2°C and 30% humidity. As a result, combustible items are concentrated to optimize the usage of the storage space available. In general, shelves almost reach the ceiling of the room and for moveable shelves only one passage is accessible at a time while the others remain closed.

Archive and library buildings

As many buildings which house archives and libraries were not designed for this purpose, there are organizational and technological challenges to be met when designing integrated fire safety solutions. It is common for historic buildings not being used by the government or armed forces to become archives or document repositories. Some of the challenges that have to be faced are:

- Old installations: outdated power, air-conditioning and lighting design, presenting a greater risk of fire
- Excessive fire load: shelves, ceilings, floors, doors and paints may not be designed for the use in an archive so that they present an additional fire load
- Over-sized rooms: modern thinking favors compartmentalization in order to create fire compartments of a particular size, keeping down the cost of the technologies required to implement an integrated fire safety solution
- Lack of fire protection means: lack of elements that make up an integrated fire safety solution such as risk analysis, contingency plans, technology that is appropriate to and in keeping with the risk analysis and training of the staff who are working in the building
- Excessive exposure to external risks: transformers, generators or service stations represent an excessive risk. Security aspects to prevent attacks also have to be considered.

In modern buildings the situation is completely different: adequate compartmentalization is in place and fire compartments are kept closed. Furthermore, power is completely shut down when the room is not being used, and the organizational and technological fire protection methods to prevent fire are applied according to the specific risk analysis for each case.

Cause of fire

Typically an electrical fault, such as a cable overheating, produces a smoldering fire which produces smoke but not much heat and which can spread over several hours. A sudden gust of

fresh air or an increase in temperature can convert it into an open-flame fire which will quickly spread through the whole room and to adjacent rooms.

Statistics from fires in archives and libraries in recent years show that fires are most commonly caused by technical faults in electrical installations, followed by human error, attacks, sabotage and natural accidents. In all cases, the scale of the cultural and economic losses is enormous. With the technologies and risk analyses available nowadays, these losses can be avoided or, at least, minimized.

Technologies such as thermal imaging and ultrasound can help in the early detection of overloads and defective appliance operation, providing significant support for fire protection technologies. These aspects are particularly relevant in old buildings.

Minimizing the impact of fire

Claus Friis, Head of Fire Protection and Safety at the Danish Royal Library is responsible for Security and Fire Safety of a conglomerate of 21 buildings and over 100.000 m², home for over 200 km of book-shelves and visited yearly by around 1.000.000 people. He explains that, in the case of a fire, three aspects have to work properly in order to minimize impact:

- Technology: Relevant, reliable and customized to the specific application needs.
- People: The right instruction and enough exercises must be performed to assure that people will react quickly, correctly and safely in emergency situations.
- Procedures: The right processes have to be defined and included in a fire safety manual, specific for each building. Each employee in the building must know the process.

Only the interaction of these three elements ensures the correct operation of an integrated fire safety concept. The reaction of individuals is considered the most critical element, and so periodic drills involving the local fire brigade, police, employees and security guards are essential.

Integrated one-stop-shop solutions

One of the most important elements of the technological aspect of the fire safety concept is the interaction of detection and extinguishing. In many cases it is also the cause of system failures. Early, reliable detection of a fire and the initiation of appropriate extinguishing measures are critical factors in an effective protection concept. Fire detection, evacuation and extinguishing systems must therefore be fully compatible with each other. Systems with real interoperability from a single source would therefore be preferable, requiring a partner with competence not only in the detection and extinguishing technologies but in the interoperability processes themselves.

Siemens offers comprehensive, one-stop solutions selecting the most appropriate system for the individual requirements providing maximum protection for people and stored items. Siemens will also take care of a system throughout its life cycle, including risk analysis, project management

and choosing the right systems and the best service provision. These integrated fire safety solutions cover every phase of the project:

- Prevention – risk analysis and consultancy to define the best safety concept
- Detection – very early and accurate smoke detection
- Response – alarming, evacuation and extinguishing
- Recover – Event analysis and quick return to operation afterwards

Prevention – Risk analysis

Extensive risk analyses are essential in buildings designed specifically for housing archives and libraries. Analyses should take into consideration aspects such as: vulnerability to natural disasters, radiation control, pest control, terrorism, sabotage, etc.

The technologies used to minimize the impact of a fire should integrate uniformly and coexist permanently with other technologies and design factors resulting from the integrated risk analysis, as shown in Figure 3.

Archives and libraries are often housed in historic buildings, where the possibilities for making modifications to incorporate technologies or adaptations aimed at reducing fire load are very limited.

From the outset, Siemens partners with architects, planners, contractors and building operators to analyze risk and provide real planning and project management. Beyond this initial consultancy role to identify and plan for the specific risks, it is important to recognize the ongoing need for maintenance and modernization throughout the life of the archive. Lifecycle management services provided by Siemens ensure the initial investment in a fire safety system is protected in the long term.

Early and reliable detection

In archives and libraries where high valuable assets are stored, very early detection is required. Sinteso optical smoke detectors from Siemens offer fast and reliable detection for smoldering fires caused by short circuits or device overloads, the main cause of fires in archives. Additionally aspirating smoke detection (ASD) devices can be installed, to assure also a very fast detection in case of strong air circulation conditions. According to the specific needs of the room where the archive or library is to be located, different detection concept might be applicable (cf. appendix). Another element in the fire detection process is the Video Fire Controller for visual alarm verification and analysis, thereby enabling the correct course of action to be taken. Once a fire alarm has been confirmed, the critical “response” process starts, whether this is evacuation, evacuation and calling the fire brigade, or evacuation and extinguishing.

Response – alarming, evacuation and extinguishing

In case of fire, alarms are set off early and evacuation is started quickly. Alarm panels that interact with effective evacuation systems ensure that people are lead by clear and precise information and instructions with voice messages to ensure an evacuation in a safe and orderly manner. Siemens recommends the voice alarm system E100 with automatic voice messages and live announcements, which are automatically activated by the fire detection system. Security forces and fire brigades intervene and take the necessary measures: the information provided by the fire panels is quick and precise, allowing staff to take appropriate action. The extinguishing process with Sinorix extinguishing solutions from Siemens is started quickly and works efficiently without causing damage to people, stored items, or the environment.

Extinguishing technologies

The choice of an appropriate extinguishing technology is a key aspect in fire safety for archives and libraries, which require quick fire extinguishing without damaging records. And precisely these elements in a competent risk analysis determine the appropriate extinguishing technology.

A fire will continue to burn as long as it has enough oxygen, heat and combustible. If one of these components is removed, the fire will immediately die out. Automated extinguishing systems function by eliminating one of these three components. Depending on the risk of fire and the application, different agents are used for extinguishing a fire such as water (e.g. sprinkler systems, water mist), gaseous extinguishing agents (chemical or natural gases), or a combination of gas and water (e.g. gas/water-combined system). Water primarily cools flammable materials and the ambient air, preventing the fire from spreading rapidly. The natural gaseous extinguishing agents primarily work by depriving the fire of oxygen (inertization) in the protected area, while the chemical gasous extinguishing agents primarily reduce the heat in the fire.

Different substances stored in archives produce different types of fire and this, together with the structural characteristics of the room, determine which extinguishing agent and technology is most appropriate.

Without any doubt, most archives and libraries are used to preserve paper items. For this type of risk, the cutting-edge Sinorix H₂O Gas technology is the best solution.

More effectiveness through nitrogen and water

Sinorix H₂O Gas combines the natural extinguishing agent nitrogen and water for a dual effect that quickly and reliably extinguishes the fire. While the nitrogen reduces the concentration of oxygen in the flooding zone, extinguishing the fire immediately, the water mist lowers the temperature to a level below the point where flammable material could ignite again.

When discharged, both extinguishing agents are carried by the same piping network and are distributed by the same nozzles to the flooding zone. The nitrogen also serves as a propellant for the water and ensures a moderate and equal distribution. Furthermore, the water mist mixture

cools down overheated equipment and surfaces providing additional protection. The water mist also reduces the risk of fire igniting again.

Thanks to the combination of nitrogen and water, this extinguishing technology is preferable to water mist, because it ensures that the fire is extinguished in all parts of the room, even inside closed shelving units. As with all gas-based technologies, it requires the room to have a certain level of airtightness. This guarantees the efficiency of the extinguishing method.

Thanks to the use of the fine spraying technology, exposed surfaces are coated with only a very thin layer of water - so thin that it is not damaging sensitive documents in the archive because it evaporates within a matter of minutes. The ultra-fine water droplets generated (diameter 10–50 µm) maximize the use of the cooling capabilities of water, as shown in Figure 4. This means that as little as 30–80 liters of water may be required for each 100 m³ protected.

All combustion processes produce toxic gases, which can hinder breathing or affect visibility for anyone still inside the room. An additional positive effect of Sinorix H₂O Gas is that the water mist causes these gases to precipitate, quickly reducing toxic fumes from the air.

The natural extinguishing agents nitrogen and water are safe for the environment and people¹.

Comprehensive fire safety solution for the Danish Royal Archives

The Danish Royal Archives are partially located in a historic building almost 400 years old that once belonged to the royal palace. Since it was founded, the archives have housed valuable documents of the Danish authorities including maps, registers of baptism, census documents, business records and many other unique documents and files. The documents that are preserved here date back to the 12th century and the shelves stretch for a total of 120 km.

Siemens and the Royal Archives had several problems to solve in their search for the appropriate fire safety solution. First, a large number of irreplaceable documents were to be protected. Next, the existing building structure had to be taken in to consideration, as the historically valuable building could only be adjusted structurally to a limited extent. Finally, the system had to be precisely adapted to the limited space available. After a thorough risk assessment and comprehensive tests, the Royal Archives selected the Sinorix H₂O Gas extinguishing system from Siemens. This system was selected particularly because it could be precisely tailored to the specific requirements of the archives, enables fires to be extinguished quickly and absolutely reliably, and its special fine spraying technology minimizes subsequent damage to the irreplaceable documents from the extinguishing.

The Danish Royal Archives are currently protected by a comprehensive fire safety solution from Siemens. The system is comprised of four fire control panels and 344 intelligent smoke detectors, two of which are aspiration smoke detectors. There are also 39 strategically located manual call

¹ The Earth's atmosphere is made up of around 78% nitrogen and 21% oxygen. Fire is extinguished if the quantity of oxygen drops to 13% by volume, a level that presents no risk to human health.

points. In addition to the storage rooms for the documents, the offices and other rooms are also monitored.

The Sinorix H₂O Gas extinguishing system for the document storage rooms encompasses 14 flooding zones with a total of 160 extinguishing cylinders with nitrogen and water. Moreover, two Sinorix N₂ extinguishing systems were installed for the IT rooms. All of the components of the solution are managed via a MM8000 danger management system from Siemens.

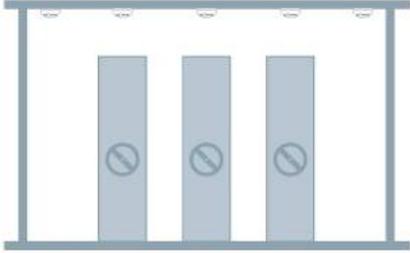
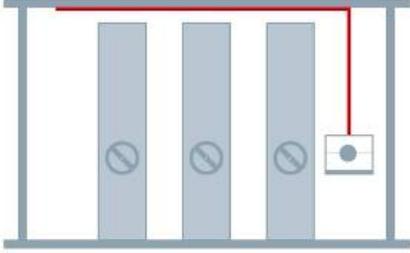
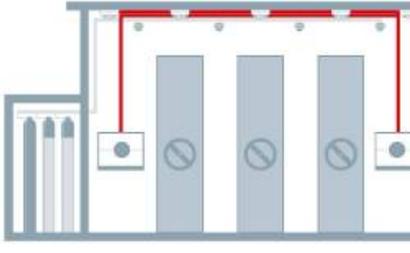
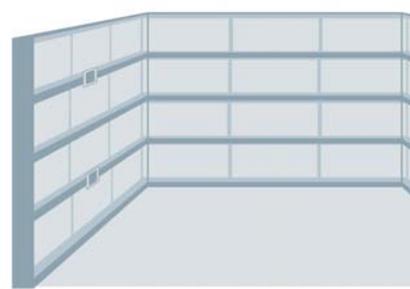
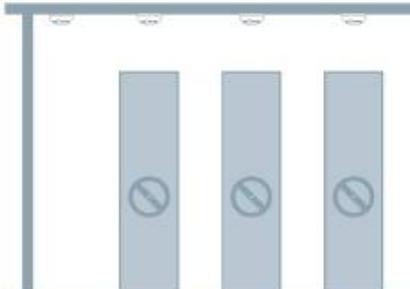
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Background Information

Cause of fire			
Month / Year	Building	Cause of fire	Damage
12 / 09	Dennenlohe Castle, Bavaria	Christmas Nativity Scene	€0.3 million, paintings and historic carpets
9 / 09	Archive in Lausanne, Switzerland holding documentation for 150 companies	Electrical fault	The whole archive and 3000m ³ of documents completely destroyed
7 / 09	Samland Museum in Pinneberg, Germany	Garden maintenance with a flamethrower	Historic monument from 1770 damaged and items in the collection destroyed
7 / 09	Küppersmühle Museum – Ströher Collection in Duisburg, Germany	Welding work	€0.1 million
6 / 08	Universal Studios Archives in Hollywood, USA	Maintenance on the building façade (tar covering applied with torch)	Several million dollars. Several film sets and the archive of 40,000 videos and film reels destroyed.
4 / 08	St. Gregory Convent in Venlo-Steyl, Germany	Arson	Museum and library completely destroyed.
2 / 08	Folkwang Museum in Essen, Germany	Electric cable	Part of theatre destroyed.
10 / 05	Transport Museum in Nuremberg: Antique locomotives, 4 km of shelving holding documents and over 10,000 items	Welding work on the museum roof	€20–40 million, a fifth of the collection's locomotives and wagons completely destroyed.
9 / 04	Duchess Anna Amalia Library in Weimar, Germany	Technical fault (exact cause still not clear)	Around €80 million. 50,000 volumes burnt including the Duchess Anna Amalia's collection of musical works. The building was restored for €12.8 million.

Source: bvfa, Germany – major fires in archives and libraries 2004-2009

Different types of detection	
<p>Detection based on point detectors:</p> <p>The minimal protection in archive is detection with fire point detector. Here Sinteso S-LINE offers unmatched detection accuracy and quick notification thanks to ASAtechnology</p>	
<p>Detection based on Aspirating Smoke Detectors (ASD)</p> <p>If the stored goods are extremely valuable and irreplaceable, a very early detection of a fire in the room is required. This solution is also suitable when the detectors are very difficult to reach (e.g. for maintenance) or very high shelves reaching almost the ceiling</p>	
<p>Combined ASD and point detectors, supplemented with extinguishing</p> <p>The ultimate protection concept for archives when high value assets are stored, combining earliest and most reliable detection with ASD and Sinteso S-LINE and the extinguish efficiency of Sinorix H₂O Gas</p>	
<p>Detection based on linear smoke detectors</p> <p>Buildings where libraries are located could present a central high opening. Linear smoke detectors are the optimal solution to protect this area of the building</p>	
<p>Detection based on wireless smoke detectors</p> <p>Libraries are often located in historical buildings, where it is not allowed to install wired detectors on the ceiling due to structure or valuable painting</p>	

Technical details for Sinorix H ₂ O Gas	
Extinguishing agents	Nitrogen (N ₂) and water (H ₂ O)
Nozzle pressure	10–60 bar
Droplet speed	50–150 m/s
Droplet size	10–50 µm
Coverage from each nozzle	30 m ²
Quantity of water used	0.3–0.8 kg/m ³ (depending on fire risk)
Piping network	Galvanized steel pipes, designed for 60 bar operating pressure
Applications	Fire classes A, B, C
Flooding time	60–120 s
Approval	VdS (S307002)

Captions

Fig. 1: Duchess Anna Amalia Library in Weimar (Germany) – Consequences of the fire in 2004
(Source: <http://www.anna-amalia-bibliothek.de/> - Klassik Stiftung Weimar)

Fig. 2: Integrated fire safety solution from Siemens for archives and libraries (Source: Siemens)

Fig. 3: Integrated risk analysis (Source: Siemens)

Fig. 4: Suitable extinguishing solution defined by the type of archive (Source: Siemens)

Fig. 5: Cooling efficiency / droplet size (Source: Siemens)

Fig. 6: Royal Archive, Denmark (Source: Siemens)

Author

Miguel Ángel Coll

Manager Applications & Offering

Siemens

Fire Safety Solutions & Services

Building Technologies Group

e-mail: miguel.coll@siemens.com